Technical Support Document (TSD): Preparation of Emissions Inventories for the 2017 North American Emissions Modeling Platform

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Technical Support Document (TSD) Preparation of Emissions Inventories for the 2017 North American Emissions Modeling Platform

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Acronyms

AADT	Annual average daily traffic
AE6	CMAQ Aerosol Module, version 6, introduced in CMAQ v5.0
AEO	Annual Energy Outlook
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AIS	Automated Identification System
APU	Auxiliary power unit
BEIS	Biogenic Emissions Inventory System
BELD	Biogenic Emissions Land use Database
BenMAP	Benefits Mapping and Analysis Program
BPS	Bulk Plant Storage
BTP	Bulk Terminal (Plant) to Pump
C1C2	Category 1 and 2 commercial marine vessels
C3	Category 3 (commercial marine vessels)
CAMD	EPA's Clean Air Markets Division
CAMx	Comprehensive Air Quality Model with Extensions
CAP	Criteria Air Pollutant
CARB	California Air Resources Board
CB05	Carbon Bond 2005 chemical mechanism
CB6	Version 6 of the Carbon Bond mechanism
CBM	Coal-bed methane
CDB	County database (input to MOVES model)
CEMS	Continuous Emissions Monitoring System
CISWI	Commercial and Industrial Solid Waste Incinerators
CMAQ	Community Multiscale Air Quality
CMV	Commercial Marine Vessel
CNG	Compressed natural gas
CO	Carbon monoxide
CONUS	Continental United States
CoST	Control Strategy Tool
CRC	Coordinating Research Council
CSAPR	Cross-State Air Pollution Rule
E0, E10, E85	0%, 10% and 85% Ethanol blend gasoline, respectively
ECA	Emissions Control Area
ECCC	Environment and Climate Change Canada
EF	Emission Factor
EGU	Electric Generating Units
EIA	Energy Information Administration
EIS	Emissions Inventory System
EPA	Environmental Protection Agency
EMFAC	EMission FACtor (California's onroad mobile model)
EPIC	Environmental Policy Integrated Climate modeling system
FAA	Federal Aviation Administration
FCCS	Fuel Characteristic Classification System
FEST-C	Fertilizer Emission Scenario Tool for CMAQ
FF10	Flat File 2010
FINN	Fire Inventory from the National Center for Atmospheric Research

FIPS	Federal Information Processing Standards
FHWA	Federal Highway Administration
HAP	Hazardous Air Pollutant
HMS	Hazard Mapping System
HPMS	Highway Performance Monitoring System
ICI	Industrial/Commercial/Institutional (boilers and process heaters)
I/M	Inspection and Maintenance
IMO	International Marine Organization
IPM	Integrated Planning Model
LADCO	Lake Michigan Air Directors Consortium
LDV	Light-Duty Vehicle
LPG	Liquified Petroleum Gas
MACT	Maximum Achievable Control Technology
MARAMA	Mid-Atlantic Regional Air Management Association
MATS	Mercury and Air Toxics Standards
MCIP	Meteorology-Chemistry Interface Processor
MMS	Minerals Management Service (now known as the Bureau of Energy Management, Regulation and Enforcement (BOEMRE)
MOVES	Motor Vehicle Emissions Simulator
MSA	Metropolitan Statistical Area
MTBE	Methyl tert-butyl ether
MWC	Municipal waste combustor
MY	Model year
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NBAFM	Naphthalene, Benzene, Acetaldehyde, Formaldehyde and Methanol
NCAR	National Center for Atmospheric Research
NEEDS	National Electric Energy Database System
NEI	National Emission Inventory
NESCAUM	Northeast States for Coordinated Air Use Management
NH_3	Ammonia
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NONROAD	OTAQ's model for estimation of nonroad mobile emissions
NO_X	Nitrogen oxides
NSPS	New Source Performance Standards
OHH	Outdoor Hydronic Heater
ONI	Off network idling
OTAQ	EPA's Office of Transportation and Air Quality
ORIS	Office of Regulatory Information System
ORD	EPA's Office of Research and Development
OSAT	Ozone Source Apportionment Technology
pcSOA	Potential combustion Secondary Organic Aerosol
PFC	Portable Fuel Container
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns
PM_{10}	Particulate matter less than or equal to 10 microns
POA	Primary Organic Aerosol
ppm	Parts per million
ppmv	Parts per million by volume

PSAT	Particulate Matter Source Apportionment Technology
RACT	Reasonably Available Control Technology
RBT	Refinery to Bulk Terminal
RIA	Regulatory Impact Analysis
RICE	Reciprocating Internal Combustion Engine
RWC	Residential Wood Combustion
RPD	Rate-per-vehicle (emission mode used in SMOKE-MOVES)
RPH	Rate-per-hour (emission mode used in SMOKE-MOVES)
RPP	Rate-per-profile (emission mode used in SMOKE-MOVES)
RPV	Rate-per-vehicle (emission mode used in SMOKE-MOVES)
RVP	Reid Vapor Pressure
SCC	Source Classification Code
SMARTFIRE2	Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOA	Secondary Organic Aerosol
SIP	State Implementation Plan
SPDPRO	Hourly Speed Profiles for weekday versus weekend
S/L/T	state, local, and tribal
TAF	Terminal Area Forecast
TCEQ	Texas Commission on Environmental Quality
TOG	Total Organic Gas
TSD	Technical support document
USDA	United States Department of Agriculture
VIIRS	Visible Infrared Imaging Radiometer Suite
VOC	Volatile organic compounds
VMT	Vehicle miles traveled
VPOP	Vehicle Population
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting Model
2014NEIv2	2014 National Emissions Inventory (NEI), version 2

1 Introduction

The U.S. Environmental Protection Agency (EPA) developed an air quality modeling platform for air toxics and criteria air pollutants that represents the year 2017 based on the 2017 National Emissions Inventory (2017 NEI) published in January 2021 (EPA, 2021). The air quality modeling platform consists of all the emissions inventories and ancillary data files used for emissions modeling, as well as the meteorological, initial condition, and boundary condition files needed to run the air quality model. This document focuses on the emissions modeling component of the 2017 modeling platform, including the emission inventories, the ancillary data files, and the approaches used to transform inventories for use in air quality modeling. Many of the emissions inventory components of this air quality modeling platform are based on the 2017 NEI, although there are some differences between the platform inventories and the 2017 NEI emissions in support of the emissions modeling process.

The modeling platform includes all criteria air pollutants and precursors (CAPs), two groups of hazardous air pollutants (HAPs) and diesel particulate matter. The first group of HAPs are those explicitly used by the chemical mechanism in the Community Multiscale Air Quality (CMAQ) model (Appel, 2018) for ozone/particulate matter (PM): chlorine (Cl), hydrogen chloride (HCl), benzene, acetaldehyde, formaldehyde, methanol, naphthalene (the last five are also abbreviated as NBAFM in subsequent sections of the document). The second group of HAPs consists of 52 HAPs or HAP groups (such as polycyclic aromatic hydrocarbon groups) added to CMAQ for the purposes of air quality modeling for the 2017 HAP+CAP platform.

Emissions were prepared for the Community Multiscale Air Quality (CMAQ) model (https://www.epa.gov/cmaq) version 5.3.1[1], which was used to model ozone (O_3) particulate matter (PM), and HAPs. CMAQ requires hourly and gridded emissions of the following inventory pollutants: carbon monoxide (CO), nitrogen oxides (NO_X), volatile organic compounds (VOC), sulfur dioxide (SO_2), ammonia (NH_3), particulate matter less than or equal to 10 microns (PM_{10}), and individual component species for particulate matter less than or equal to 2.5 microns ($PM_{2.5}$). In addition, the Carbon Bond mechanism version 6 (CB6) with chlorine chemistry within CMAQ allows for explicit treatment of the VOC HAPs naphthalene, benzene, acetaldehyde, formaldehyde and methanol (NBAFM), includes anthropogenic HAP emissions of HCl and Cl, and can model additional HAPs as described in Section 3. The short abbreviation for the modeling case name was “2017gb”, where 2017 is the year modeled, g represents that it was based on the 2017 NEI, and b represents that it was the second version of the 2017NEI-based platform.

Emissions were also prepared for an air dispersion modeling system: American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) (EPA, 2018). AERMOD was run for all NEI HAPs (about 130 more than covered by CMAQ) across all 50 states, Puerto Rico and the Virgin Islands. This TSD focuses on the CMAQ aspects of the modeling platform.

[1] CMAQv5.3.1 was run in a multi-pollutant configuration using the CB6R3 chemical mechanism with AERO7, nonvolatile primary organic aerosols (POA) and without pcSOA (The case abbreviation was 2017gb_MP_cb6ae7_17j_12US2).

The effort to create the 2017 emission inputs for this study included development of emission inventories for input to a 2017 modeling case, along with application of emissions modeling tools to convert the inventories into the format and resolution needed by CMAQ and AERMOD. The emissions modeling platform includes point sources, nonpoint sources, commercial marine vessels (CMV), onroad and nonroad mobile sources, biogenic emissions and fires for the U.S., Canada, and Mexico. Some platform categories use more disaggregated data than are made available in the NEI. For example, in the platform, onroad mobile source emissions are represented as hourly emissions by vehicle type, fuel type process and road type while the NEI emissions are aggregated to vehicle type/fuel type totals and annual temporal resolution. Emissions from Canada and Mexico are used in the CMAQ modeling but are not part of the NEI. Year-specific emissions were used for all source categories, including fires and continuous emission monitoring system (CEMS) data for electric generating units (EGUs).

The primary emissions modeling tool used to create the CMAQ model-ready emissions was the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system. SMOKE version 4.7 was used to create CMAQ-ready emissions files for a 12-km national grid. Additional information about SMOKE is available from http://www.cmascenter.org/smoke.

The gridded meteorological model used to provide input data for the emissions modeling was developed using the Weather Research and Forecasting Model (WRF, https://ral.ucar.edu/solutions/products/weather-research-and-forecasting-model-wrf) version 3.8, Advanced Research WRF core (Skamarock, et al., 2008). The WRF Model is a mesoscale numerical weather prediction system developed for both operational forecasting and atmospheric research applications. The WRF was run for 2017 over a domain covering the continental U.S. at a 12km resolution with 35 vertical layers. The run for this platform included high resolution sea surface temperature data from the Group for High Resolution Sea Surface Temperature (GHRSST) (see https://www.ghrsst.org/) and is given the EPA meteorological case abbreviation “17j.” The full case abbreviation includes this suffix following the emissions portion of the case name to fully specify the abbreviation of the case as “2017gb_17j.”

Following the emissions modeling steps to prepare emissions for CMAQ and AERMOD, both models were run. CMAQ outputs provide the overall mass, chemistry and formation for specific hazardous air pollutants (HAPs) formed secondarily in the atmosphere (e.g., formaldehyde, acetaldehyde and acrolein), whereas AERMOD provides spatial granularity and more detailed source attribution. CMAQ also provided the biogenic and fire concentrations, as these sources are not run in AERMOD. Only AERMOD was run in Alaska, Hawaii, Puerto Rico and the Virgin Islands. Special steps were taken to estimate secondary HAPs, fire and biogenic emissions in these areas. The outputs from CMAQ and AERMOD were combined to provide spatially refined concentration estimates for HAPs, from which estimates of cancer and non-cancer risk were derived. Information about the emissions and associated data files for this platform are available from this section of the air emissions modeling website https://www.epa.gov/air-emissions-modeling/2017-emissions-modeling-platform.

This document contains five sections and several appendices. Section 2 describes the 2017 inventories input to SMOKE. Section 3 describes the emissions modeling and the ancillary files used to process the emission inventories into air quality model-ready inputs. Data summaries are provided in Section 4. Section 5 provides references. The Appendices provide additional details about specific technical methods or data.

2 Emissions Inventories and Approaches

This section describes the emissions inventories created for input to SMOKE, which are based on the version of the 2017 NEI released in January 2021. The NEI includes five main data categories: a) nonpoint (formerly called "stationary area") sources; b) point sources; c) nonroad mobile sources; d) onroad mobile sources; and e) fires. For CAPs, the NEI data are largely compiled from data submitted by state, local and tribal (S/L/T) agencies. HAP emissions data are often augmented by EPA when they are not voluntarily submitted to the NEI by S/L/T agencies. The NEI was compiled using the Emissions Inventory System (EIS). EIS includes hundreds of automated QA checks to improve data quality, and it also supports release point (stack) coordinates separately from facility coordinates. EPA collaboration with S/L/T agencies helped prevent duplication between point and nonpoint source categories such as industrial boilers. The 2017 NEI Technical Support Document describes in detail the development of the 2017 emission inventories and is available at https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-technical-support-document-tsd (EPA, 2021).

Point source data from the 2017 NEI, including data submitted to EIS by S/L/T agencies, were used for this study. EPA used the SMARTFIRE2 system and the BlueSky emissions modeling framework to develop year 2017 fire emissions. SMARTFIRE2 categorizes all fires as either prescribed burning or wildfire categories, and the BlueSky framework includes emission factor estimates for both types of fires. Onroad and nonroad mobile source emissions for year 2017 were developed by running MOVES2014b (https://www.epa.gov/moves). Canadian emissions interpolated to the year 2017 from 2015 and 2023 were used, and Mexican emissions were for the year 2016.

The emissions modeling process, performed using SMOKE v4.7, apportions the emissions inventories into the grid cells used by CMAQ and temporalizes the emissions into hourly values. In addition, the pollutants in the inventories (e.g., NOx, PM and VOC) are split into the chemical species needed by CMAQ. For the purposes of preparing the CMAQ- ready emissions, the NEI emissions inventories by data category are split into emissions modeling platform "sectors"; and emissions from sources other than the NEI are added, such as the Canadian, Mexican, and offshore inventories. Emissions within the emissions modeling platform are separated into sectors for groups of related emissions source categories that are run through all of the SMOKE programs, except the final merge, independently from emissions categories in the other sectors. The final merge program called Mrggrid combines low-level sector-specific gridded, speciated and temporalized emissions to create the final CMAQ-ready emissions inputs. For biogenic emissions, the CMAQ model allows for biogenic emissions to be included in the CMAQ-ready emissions inputs, or for biogenic emissions to be computed within CMAQ itself (the "inline" option). This study uses the inline biogenic emissions option.

Table 2-1 presents the sectors in the emissions modeling platform used to develop the year 2017 emissions for this project. The sector abbreviations are provided in italics; these abbreviations are used in the SMOKE modeling scripts, the inventory file names, and throughout the remainder of this section.

Table 2-1. Platform sectors used in the Emissions Modeling Process

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
EGU units: ***ptegu***	Point	2017 NEI point source EGUs, replaced with hourly 2017 Continuous Emissions Monitoring System (CEMS) values for NO_X and SO_2 where the units are matched to the NEI. Emissions for all sources not matched to CEMS data come from 2017 NEI point inventory. Annual resolution for sources not matched to CEMS data, hourly for CEMS sources.
Point source oil and gas: ***pt_oilgas***	Point	2017 NEI point sources that include oil and gas production emissions processes for facilities with North American Industry Classification System (NAICS) codes related to Oil and Gas Extraction, Natural Gas Distribution, Drilling Oil and Gas Wells, Support Activities for Oil and Gas Operations, Pipeline Transportation of Crude Oil, and Pipeline Transportation of Natural Gas. Includes U.S. offshore oil production. Annual resolution.
Aircraft and ground support equipment: ***airports***	Point	2017 NEI point source emissions from airports, including aircraft and airport ground support emissions. Annual resolution. The January 2021 version of 2017 NEI corrected the aircraft emissions in the April 2020 release of the 2017 NEI.
Remaining non-EGU point: ***ptnonipm***	Point	All 2017 NEI point source records not matched to the airports, ptegu, or pt_oilgas sectors. Includes 2017-specific rail yard emissions. Annual resolution.
Agricultural fertilizer: ***ag***	Nonpoint	2017 NEI nonpoint livestock and fertilizer application emissions. Livestock includes ammonia and other pollutants (except PM2.5). Fertilizer includes only ammonia. County and annual resolution.
Agricultural fires with point resolution: ***ptagfire***	Nonpoint	Agricultural fire sources for year 2017 that were developed by EPA as point and day-specific emissions.[2] Agricultural fires are in the nonpoint data category of the NEI, but in the modeling platform, they are treated as day-specific point sources.
Area fugitive dust: ***afdust_adj***	Nonpoint	PM_{10} and $PM_{2.5}$ fugitive dust sources from the 2017 NEI nonpoint inventory; including building construction, road construction, agricultural dust, and paved and unpaved road dust. The emissions modeling system applies a transport fraction reduction and a zero-out based on 2017 gridded hourly meteorology (precipitation and snow/ice cover). Emissions are county and annual resolution.
Biogenic: ***beis***	Nonpoint	Year 2017 emissions from biogenic sources. These were left out of the CMAQ-ready merged emissions, in favor of inline biogenic emissions produced during the CMAQ model run itself.
Category 1, 2 CMV: ***cmv_c1c2***	Nonpoint	2017 NEI Category 1 (C1) and Category 2 (C2), commercial marine vessel (CMV) emissions based on Automatic Identification System (AIS) data. Point and hourly resolution.
Category 3 CMV: ***cmv_c3***	Nonpoint	Within state and federal waters, 2017 NEI Category 3 commercial marine vessel (CMV) emissions based on AIS data. Outside of state and federal waters, emissions are based on AIS data in selected areas, and are gapfilled with emissions from the Emissions Control Area (ECA) inventory. Point and hourly resolution.
Locomotives : ***rail***	Nonpoint	Line haul rail locomotives emissions for year 2017. County and annual resolution.

[2] Only EPA-developed agricultural fire data were included in this study; data submitted by states to the NEI were excluded.

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
Nonpoint source oil and gas: ***np_oilgas***	Nonpoint	Nonpoint 2017 NEI sources from oil and gas-related processes. County and annual resolution.
Residential Wood Combustion: ***rwc***	Nonpoint	2017 NEI nonpoint sources with residential wood combustion (RWC) processes. County and annual resolution.
Remaining nonpoint: ***nonpt***	Nonpoint	2017 NEI nonpoint sources not included in other platform sectors, including solvents. County and annual resolution.
Nonroad: ***nonroad***	Nonroad	2017 nonroad equipment emissions developed with MOVES2014b. MOVES was used for all states except California, which submitted their own emissions for the 2017 NEI. County and monthly resolution.
Onroad: ***onroad***	Onroad	2017 onroad mobile source gasoline and diesel vehicles from parking lots and moving vehicles. Includes the following emission processes: exhaust, extended idle, auxiliary power units, evaporative, permeation, refueling, and brake and tire wear. For all states except California, developed using winter and summer MOVES emission factors tables produced by MOVES2014b.
Onroad California: ***onroad_ca_adj***	Onroad	California-provided 2017 CAP and metal HAP onroad mobile source gasoline and diesel vehicles from parking lots and moving vehicles based on Emission Factor (EMFAC) 2017, gridded and temporalized based on outputs from MOVES2014b. Volatile organic compound (VOC) HAP emissions derived from California-provided VOC emissions and MOVES-based speciation.
Point source fires- ***ptfire***	Events	Point source day-specific wildfires and prescribed fires for 2017 computed using SMARTFIRE 2 and BlueSky.
Non-US. Fires: ***ptfire_othna***	N/A	Point source day-specific wildfires and agricultural fires outside of the U.S. for 2017 from v1.5 of the Fire INventory (FINN) from National Center for Atmospheric Research (NCAR, 2017 and Wiedinmyer, C., 2011) for Canada, Mexico, Caribbean, Central American, and other international fires.
Other Area Fugitive dust sources not from the NEI: ***othafdust***	N/A	Area fugitive dust sources from Canada interpolated to 2017 between 2015 and 2023, with transport fraction and snow/ice adjustments based on 2017 meteorological data. Annual and province resolution.
Other Point Fugitive dust sources not from the NEI: ***othptdust***	N/A	2017 point source fugitive dust sources from Canada interpolated between 2015 and 2023, with transport fraction and snow/ice adjustments based on 2017 meteorological data. Annual and province resolution.
Other point sources not from the NEI: ***othpt***	N/A	2017 Canada point source emissions interpolated between 2015 and 2023, and Mexico point source emissions for 2016 (provided by SEMARNAT). Annual and monthly resolution.
Other non-NEI nonpoint and nonroad: ***othar***	N/A	Year 2017 Canada interpolated between 2015 and 2023 (province resolution) and projected year 2016 Mexico (municipio resolution, provided by SEMARNAT) nonpoint and nonroad mobile inventories, annual resolution.
Other non-NEI onroad sources: ***onroad_can***	N/A	Monthly onroad mobile inventory for Canada interpolated to 2017 between 2015 and 2023 (province resolution).

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
Other non-NEI onroad sources: ***onroad_mex***	N/A	Monthly onroad mobile inventory from MOVES-Mexico (municipio resolution) for 2017.

Other natural emissions are also merged in with the above sectors: ocean chlorine, sea salt, and volcanic mercury. The ocean chlorine gas emission estimates are based on the build-up of molecular chlorine (Cl_2) concentrations in oceanic air masses (Bullock and Brehme, 2002). In CMAQ, the species name is "CL2". The sea salt emissions were developed with version 4.1 of the OCEANIC pre-processor that comes with the CAMx model. The preprocessor estimates time/space-varying emissions of aerosol sodium, chloride and sulfate; gas-phase chlorine and bromine associated with sea salt; gaseous halo-methanes; and dimethyl sulfide (DMS). These additional oceanic emissions are incorporated into the final model-ready emissions files for CAMx.

The emission inventories in SMOKE input formats for the platform are available from EPA's Air Emissions Modeling website: https://www.epa.gov/air-emissions-modeling/2017-emissions-modeling-platform. The platform informational text file indicates the particular zipped files associated with each platform sector. Some emissions data summaries are available with the data files for the 2017 platform. The types of reports include state summaries of inventory pollutants and model species by modeling platform sector and county annual totals by modeling platform sector.

2.1 Point sources (ptegu, pt_oilgas, ptnonipm, airports)

Point sources are sources of emissions for which specific geographic coordinates (e.g., latitude/longitude) are specified, as in the case of an individual facility. A facility may have multiple emission release points that may be characterized as units such as boilers, reactors, spray booths, kilns, etc. A unit may have multiple processes (e.g., a boiler that sometimes burns residual oil and sometimes burns natural gas). With a couple of minor exceptions, this section describes only NEI point sources within the contiguous U.S. The offshore oil platform (pt_oilgas sector) and CMV emissions (cmv_c1c2 and cmv_c3 sectors) are processed by SMOKE as point source inventories and are discussed later in this section. A complete NEI is developed every three years, with 2017 being the most recently finished complete NEI. A comprehensive description about the development of the 2017 NEI is available in the 2017 NEI TSD (EPA, 2021). Point inventories are also available in EIS for intermediate years such as 2018. In the intermediate point inventories, states are required to update larger sources with emissions for the interim year, while sources not updated by states are either carried forward from the most recent NEI or marked as closed and removed.

In preparation for modeling, the complete set of point sources in the NEI was exported from EIS for the year 2017 into the Flat File 2010 (FF10) format that is compatible with SMOKE (see https://www.cmascenter.org/smoke/documentation/4.7/html/ch08s02s08.html) and was then split into several sectors for modeling. After dropping sources without specific locations (i.e., the FIPS code ends in 777), initial versions of inventories for the other three point source sectors were created from the remaining point sources. The point sectors are: EGUs (ptegu), point source oil and gas extraction-related sources (pt_oilgas), airport emissions (airports), and the remaining non-EGUs (ptnonipm). The EGU emissions are split out from the other sources to facilitate the use of distinct SMOKE temporal processing and future-year projection techniques. The oil and gas sector emissions (pt_oilgas) and airport emissions (airports) were processed separately for summary tracking purposes and distinct projection techniques from the remaining non-EGU emissions (ptnonipm).

The inventory pollutants processed through SMOKE for the ptegu, pt_oilgas, ptnonipm, and airports sectors included: CO, NO_X, VOC, SO_2, NH_3, PM_{10}, and $PM_{2.5}$ and the following HAPs: HCl (pollutant code = 7647010), Cl (code = 7782505), and several dozen other HAPs listed in Section 3. NBAFM pollutants from the point sectors were utilized for the HAP+CAP version of the platform. For cases not focused on HAPs, they are not used and instead are speciated from VOC without the use (i.e., integration) of VOC HAP pollutants from the inventory.

The ptnonipm, pt_oilgas, and airports sector emissions were provided to SMOKE as annual emissions. For sources in the ptegu sector that could be matched to 2017 CEMS data, hourly CEMS NO_X and SO_2 emissions for 2017 from EPA's Acid Rain Program were used rather than annual inventory emissions. For all other pollutants (e.g., VOC, $PM_{2.5}$, HCl), annual emissions were used as-is from the annual inventory but were allocated to hourly values using heat input from the CEMS data. For the unmatched units in the ptegu sector, annual emissions were allocated to daily values using IPM region- and pollutant-specific profiles, and similarly, region- and pollutant-specific diurnal profiles were applied to create hourly emissions.

The non-EGU stationary point source (ptnonipm) emissions were input to SMOKE as annual emissions. The full description of how the NEI emissions were developed is provided in the NEI documentation - a brief summary of their development follows:

a. CAP and HAP data were provided by States, locals and tribes under the Air Emissions Reporting Rule (AERR) [the reporting size threshold is larger for inventory years between the triennial inventory years of 2011, 2014, 2017, …].

b. EPA corrected known issues and filled PM data gaps.

c. EPA added HAP data from the Toxic Release Inventory (TRI) where corresponding data was not already provided by states/locals.

d. EPA stored and applied matches of the point source units to units with CEMS data and also for all EGU units modeled by EPA's Integrated Planning Model (IPM).

e. Data for airports and rail yards were incorporated.

f. Off-shore platform data were added from the Bureau of Ocean Energy Management (BOEM).

The changes made to the NEI point sources prior to modeling with SMOKE are as follows:

- The tribal data, which do not use state/county Federal Information Processing Standards (FIPS) codes in the NEI, but rather use the tribal code, were assigned a state/county FIPS code of 88XXX, where XXX is the 3-digit tribal code in the NEI. This change was made because SMOKE requires all sources to have a state/county FIPS code.

- Sources that did not have specific counties assigned (i.e., the county code ends in 777) were not included in the modeling because it was only possible to know the state in which the sources resided, but no more specific details related to the location of the sources were available.

Each of the point sectors is processed separately through SMOKE as described in the following subsections.

2.1.1 EGU sector (ptegu)

The ptegu sector contains emissions from EGUs in the 2017 point source inventory that could be matched to units found in the National Electric Energy Database System (NEEDS) v6 that is used by the Integrated Planning Model (IPM) to develop future year EGU emissions. It was necessary to put these EGUs into a separate sector in the platform because EGUs use different temporal profiles than other sources in the point sector and it is useful to segregate these emissions from the rest of the point sources to facilitate summaries of the data. Sources not matched to units found in NEEDS are placed into the pt_oilgas or ptnonipm sectors. For studies with future year cases, the sources in the ptegu sector are fully replaced with the emissions output from IPM. It is therefore important that the matching between the NEI and NEEDS database be as complete as possible because there can be double-counting of emissions in future year modeling scenarios if emissions for units are projected by IPM are not properly matched to the units in the point source inventory.

The ptegu emissions inventory is a subset of the point source flat file exported from the Emissions Inventory System (EIS). The 2017 point source emissions were selected from the 2017 NEI_Final dataset on June 18, 2020 which included submissions from states up through that time. In the point source flat file, emission records for sources that have been matched to the NEEDS database have a value filled into the IPM_YN column based on the matches stored within EIS. Thus, unit-level emissions were split into a separate EGU flat file for units that have a populated (non-null) ipm_yn field. A populated ipm_yn field indicates that a match was found for the EIS unit in the NEEDS v6 database. Updates were made to the flat file output from EIS as described in the list below:

- ORIS facility and unit identifiers were updated based on additional matches in a cross-platform spreadsheet, based on state comments, and using the EIS alternate identifiers table as described later in this section.

Some units in the ptegu sector are matched to Continuous Emissions Monitoring System (CEMS) data via Office of Regulatory Information System (ORIS) facility codes and boiler IDs. For the matched units, the annual emissions of NO_X and SO_2 in the flat file are replaced with the hourly CEMS emissions in base year modeling. For other pollutants at matched units, the hourly CEMS heat input data are used to allocate the NEI annual emissions to hourly values. All stack parameters, stack locations, and Source Classification Codes (SCC) for these sources come from the flat file. If CEMS data exists for a unit, but the unit is not matched to the NEI, the CEMS data for that unit are not used in the modeling platform. However, if the source exists in the NEI and is not matched to a CEMS unit, the emissions from that source are still modeled using the annual emission value in the NEI temporally allocated to hourly values.

EIS stores many matches from NEI units to the ORIS facility codes and boiler IDs used to reference the CEMS data. In the flat file, emission records for point sources matched to CEMS data have values filled into the ORIS_FACILITY_CODE and ORIS_BOILER_ID columns. The CEMS data are available at http://ampd.epa.gov/ampd near the bottom of the “Prepackaged Data” tab. Many smaller emitters in the CEMS program cannot be matched to the NEI due to inconsistencies in the way a unit is defined between the NEI and CEMS datasets, or due to uncertainties in source identification such as inconsistent plant names in the two data systems. In addition, the NEEDS database of units modeled by IPM includes many smaller emitting EGUs that do not have CEMS. Therefore, there will be more units in the ptegu sector than have CEMS data.

Matches from the NEI to ORIS codes and the NEEDS database were improved in the 2017 platform where applicable. In some cases, NEI units in EIS match to many CAMD units. In these cases, a new entry was made in the flat file with a "_M_" in the ipm_yn field of the flat file to indicate that there are "multiple" ORIS IDs that match that unit. This helps facilitate appropriate temporal allocation of the emissions by SMOKE. Temporal allocation for EGUs is discussed in more detail in the Ancillary Data section below.

The EGU flat file was split into two flat files: those that have unit-level matches to CEMS data using the oris_facility_code and oris_boiler_id fields and those that do not so that different temporal profiles could be applied. In addition, the hourly CEMS data were processed through v2.1 of the CEMCorrect tool to mitigate the impact of unmeasured values in the data.

2.1.2 Point source oil and gas sector (pt_oilgas)

The pt_oilgas sector consists of point source oil and gas emissions in United States, primarily pipeline-transportation and some upstream exploration and production. Sources in the pt_oilgas sector consist of sources which are not electricity generating units (EGUs) and which have a North American Industry Classification System (NAICS) code corresponding to oil and gas exploration, production, pipeline-transportation or distribution. The pt_oilgas sector was separated from the ptnonipm sector by selecting sources with specific NAICS codes shown in Table 2-2. The use of NAICS to separate out the point oil and gas emissions forces all sources within a facility to be in this sector, as opposed to ptegu where sources within a facility can be split between ptnonipm and ptegu sectors.

Table 2-2. Point source oil and gas sector NAICS Codes

NAICS	NAICS description
2111	Oil and Gas Extraction
211111	Crude Petroleum and Natural Gas Extraction
211112	Natural Gas Liquid Extraction
21112	Crude Petroleum Extraction
211120	Crude Petroleum Extraction
21113	Natural Gas Extraction
211130	Natural Gas Extraction
213111	Drilling Oil and Gas Wells
213112	Support Activities for Oil and Gas Operations
2212	Natural Gas Distribution
22121	Natural Gas Distribution
221210	Natural Gas Distribution
237120	Oil and Gas Pipeline and Related Structures Construction
4861	Pipeline Transportation of Crude Oil
48611	Pipeline Transportation of Crude Oil
486110	Pipeline Transportation of Crude Oil
4862	Pipeline Transportation of Natural Gas
48621	Pipeline Transportation of Natural Gas
486210	Pipeline Transportation of Natural Gas

2.1.3 Non-IPM sector (ptnonipm)

With some exceptions, the non-IPM (ptnonipm) sector contains the point sources that are not in the ptegu, pt_oilgas, or airports sectors. For the most part, the ptnonipm sector reflects the non-EGU sources of the 2017 NEI point inventory; however, it is likely that some low-emitting EGUs not matched to the NEEDS database or to CEMS data may be found in the ptnonipm sector.

The ptnonipm sector contains a small amount of fugitive dust PM emissions from vehicular traffic on paved or unpaved roads at industrial facilities, coal handling at coal mines, and grain elevators. Sources with state/county FIPS code ending with “777” are in the NEI but are not included in any modeling sectors. These sources typically represent mobile (temporary) asphalt plants that are only reported for some states, and are generally in a fixed location for only a part of the year and are therefore difficult to allocate to specific places and days as is needed for modeling. Therefore, these sources are dropped from the point-based sectors in the modeling platform.

The ptnonipm sources (i.e., not EGUs and non -oil and gas sources) were used as-is from the 2017 NEI point inventory. Emissions from rail yards are included in the ptnonipm sector.

2.1.4 Aircraft and ground support equipment (airports)

Emissions at airports were separated from other sources in the point inventory based on sources that have the facility source type of 100 (airports). The airports sector includes all aircraft types used for public, private, and military purposes and aircraft ground support equipment. The Federal Aviation Administration’s (FAA) Aviation Environmental Design Tool (AEDT) is used to estimate emissions for this sector. For 2017, Texas and California submitted aircraft emissions. Additional information about aircraft emission estimates can be found in section 3.2.2 of the 2017 NEI TSD. The SCCs included in the airport sector are shown in Table 2-3.

Table 2-3. SCCs for the airports sector

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2260008005	Mobile Sources	Off-highway Vehicle Gasoline	Airport Ground Support Equipment	2-Stroke Airport Ground Support Equipment
2265008005	Mobile Sources	Off-highway Vehicle Gasoline	Airport Ground Support Equipment	4-Stroke Airport Ground Support Equipment
2267008005	Mobile Sources	Off-highway Vehicle LPG	Airport Ground Support Equipment	LPG Airport Ground Support Equipment
2268008005	Mobile Sources	Off-highway Vehicle CNG	Airport Ground Support Equipment	CNG Airport Ground Support Equipment
2270008005	Mobile Sources	Off-highway Vehicle Diesel	Airport Ground Support Equipment	Airport Ground Support Equipment
2275001000	Mobile Sources	Aircraft	Military Aircraft	Total
2275020000	Mobile Sources	Aircraft	Commercial Aircraft	Total: All Types
2275050011	Mobile Sources	Aircraft	General Aviation	Piston

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2275050012	Mobile Sources	Aircraft	General Aviation	Turbine
2275060011	Mobile Sources	Aircraft	Air Taxi	Piston
2275060012	Mobile Sources	Aircraft	Air Taxi	Turbine
2275070000	Mobile Sources	Aircraft	Aircraft Auxiliary Power Units	Total
40600307	Chemical Evaporation	Transportation and Marketing of Petroleum Products	Gasoline Retail Operations – Stage I	Underground Tank: Breathing and Emptying
20200102	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Reciprocating

2.2 Nonpoint sources (afdust, fertilizer, livestock, np_oilgas, rwc, solvents, nonpt)

This section describes the *stationary* nonpoint sources in the NEI nonpoint data category. Locomotives, C1 and C2 CMV, and C3 CMV are included in the NEI nonpoint data category, but are mobile sources that are described in Section 2.4.

Nonpoint tribal emissions submitted to the NEI are dropped during spatial processing with SMOKE due to the configuration of the spatial surrogates. Part of the reason for this is to prevent possible double-counting with county-level emissions and also because spatial surrogates for tribal data are not currently available. These omissions are not expected to have an impact on the results of the air quality modeling at the 12-km resolution used for this platform.

The following subsections describe how the sources in the NEI nonpoint inventory were separated into modeling platform sectors, along with any data that were updated replaced with non-NEI data.

2.2.1 Area fugitive dust sector (afdust)

The area-source fugitive dust (afdust) sector contains PM_{10} and $PM_{2.5}$ emission estimates for nonpoint SCCs identified by EPA as dust sources. Categories included in the afdust sector are paved roads, unpaved roads and airstrips, construction (residential, industrial, road and total), agriculture production, and mining and quarrying. It does not include fugitive dust from grain elevators, coal handling at coal mines, or vehicular traffic on paved or unpaved roads at industrial facilities because these are treated as point sources so they are properly located. Table 2-4 is a listing of the Source Classification Codes (SCCs) in the afdust sector.

Table 2-4. Afdust sector SCCs

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2275085000	Mobile Sources	Aircraft	Unpaved Airstrips	Total
2294000000	Mobile Sources	Paved Roads	All Paved Roads	Total: Fugitives
2294000002	Mobile Sources	Paved Roads	All Paved Roads	Total: Sanding/Salting - Fugitives
2296000000	Mobile Sources	Unpaved Roads	All Unpaved Roads	Total: Fugitives
2311000000	Industrial Processes	Construction: SIC 15 - 17	All Processes	Total

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2311010000	Industrial Processes	Construction: SIC 15 - 17	Residential	Total
2311010070	Industrial Processes	Construction: SIC 15 - 17	Residential	Vehicle Traffic
2311020000	Industrial Processes	Construction: SIC 15 - 17	Industrial/Commercial/ Institutional	Total
2311030000	Industrial Processes	Construction: SIC 15 - 17	Road Construction	Total
2325000000	Industrial Processes	Mining and Quarrying: SIC 14	All Processes	Total
2325060000	Industrial Processes	Mining and Quarrying: SIC 10	Lead Ore Mining and Milling	Total
2801000000	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture – Crops	Total
2801000003	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture – Crops	Tilling
2801000005	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture – Crops	Harvesting
2801000007	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture – Crops	Loading
2801000008	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture - Crops	Transport
2805001000	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle - finishing operations on feedlots (drylots)	Dust Kicked-up by Hooves (use 28-05-020, -001, -002, or -003 for Waste
2805001100	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle - finishing operations on feedlots (drylots)	Confinement
2805001200	Miscellaneous Area Sources	Agriculture Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Manure handling and storage
2805001300	Miscellaneous Area Sources	Agriculture Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Land application of manure
2805002000	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle production composite	Not Elsewhere Classified
2805003100	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle - finishing operations on pasture/range	Confinement
2805007100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with dry manure management systems	Confinement
2805007300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with dry manure management systems	Land application of manure
2805008100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with wet manure management systems	Confinement
2805008200	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with wet manure management systems	Manure handling and storage
2805008300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with wet manure management systems	Land application of manure
2805009100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production – broilers	Confinement
2805009200	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - broilers	Manure handling and storage
2805009300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - broilers	Land application of manure

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805010100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Confinement
2805010200	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Manure handling and storage
2805010300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Land application of manure
2805018000	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle composite	Not Elsewhere Classified
2805019100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - flush dairy	Confinement
2805019200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - flush dairy	Manure handling and storage
2805019300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - flush dairy	Land application of manure
2805020002	Miscellaneous Area Sources	Ag. Production - Livestock	Cattle and Calves Waste Emissions	Beef Cows
2805021100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - scrape dairy	Confinement
2805021200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - scrape dairy	Manure handling and storage
2805021300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - scrape dairy	Land application of manure
2805022100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - deep pit dairy	Confinement
2805022200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - deep pit dairy	Manure handling and storage
2805022300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - deep pit dairy	Land application of manure
2805023100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - drylot/pasture dairy	Confinement
2805023200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - drylot/pasture dairy	Manure handling and storage
2805023300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - drylot/pasture dairy	Land application of manure
2805025000	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production composite	Not Elsewhere Classified (see also 28-05-039, -047, -053)
2805030000	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry Waste Emissions	Not Elsewhere Classified (see also 28-05-007, -008, -009)
2805030007	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry Waste Emissions	Ducks
2805030008	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry Waste Emissions	Geese
2805035000	Miscellaneous Area Sources	Ag. Production - Livestock	Horses and Ponies Waste Emissions	Not Elsewhere Classified
2805039100	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production - operations with lagoons (unspecified animal age)	Confinement
2805039200	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production - operations with lagoons (unspecified animal age)	Manure handling and storage

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805039300	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production - operations with lagoons (unspecified animal age)	Land application of manure
2805040000	Miscellaneous Area Sources	Ag. Production - Livestock	Sheep and Lambs Waste Emissions	Total
2805045000	Miscellaneous Area Sources	Ag. Production – Livestock	Goats Waste Emissions	Not Elsewhere Classified
2805047100	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - deep-pit house operations (unspecified animal age)	Confinement
2805047300	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - deep-pit house operations (unspecified animal age)	Land application of manure
2805053100	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - outdoor operations (unspecified animal age)	Confinement

<u>Area Fugitive Dust Transport Fraction</u>

The afdust sector is separated from other nonpoint sectors to allow for the application of a “transport fraction,” and meteorological/precipitation reductions. These adjustments are applied using a script that applies land use-based gridded transport fractions based on landscape roughness, followed by another script that zeroes out emissions for days on which at least 0.01 inches of precipitation occurs or there is snow cover on the ground. The land use data used to reduce the NEI emissions determines the amount of emissions that are subject to transport. This methodology is discussed in Pouliot, et al., 2010, and in “Fugitive Dust Modeling for the 2008 Emissions Modeling Platform” (Adelman, 2012). Both the transport fraction and meteorological adjustments are based on the gridded resolution of the platform (i.e., 12km grid cells); therefore, different emissions will result if the process were applied to different grid resolutions. A limitation of the transport fraction approach is the lack of monthly variability that would be expected with seasonal changes in vegetative cover. While wind speed and direction are not accounted for in the emissions processing, the hourly variability due to soil moisture, snow cover and precipitation is accounted for in the subsequent meteorological adjustment.

For the data compiled into the 2017 NEI, meteorological adjustments are applied to paved and unpaved road SCCs but not transport adjustments. The meteorological adjustments that were applied (to paved and unpaved road SCCs) in the 2017 NEI were backed out so that the entire sector could be processed consistently in SMOKE and the same grid-specific transport fractions and meteorological adjustments could be applied sector-wide. Thus, the FF10 that is run through SMOKE consists of 100% unadjusted emissions, and after SMOKE all afdust sources have both transport and meteorological adjustments applied. The total impacts of the transport fraction and meteorological adjustments are shown in Table 2-5.

Table 2-5. Total impact of 2017 fugitive dust adjustments to unadjusted inventory

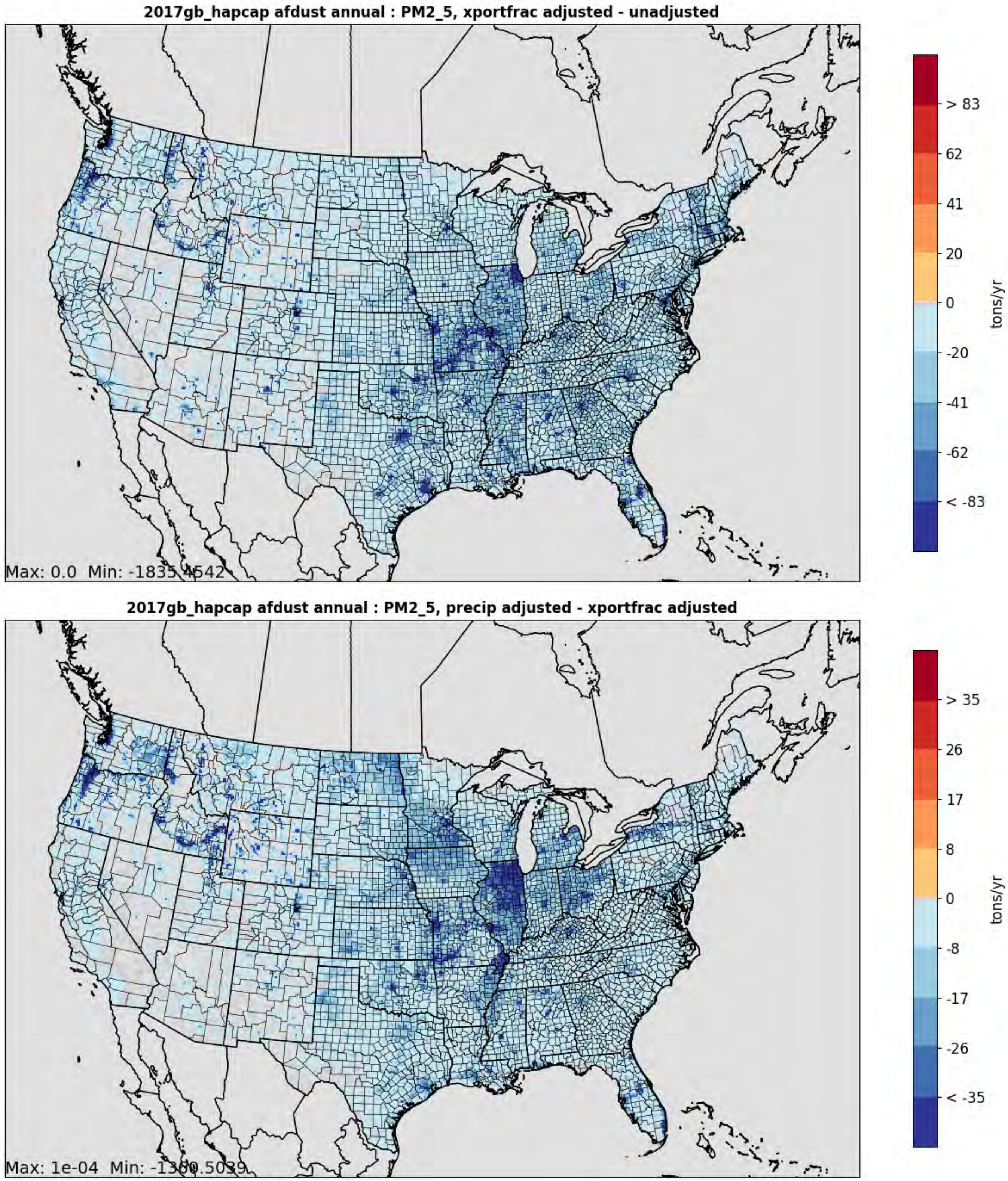
State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
Alabama	306,333	41,208	-219,542	-29,507	72%	72%
Arizona	181,281	24,286	-65,373	-8,554	36%	35%
Arkansas	394,400	54,447	-267,830	-36,303	68%	67%

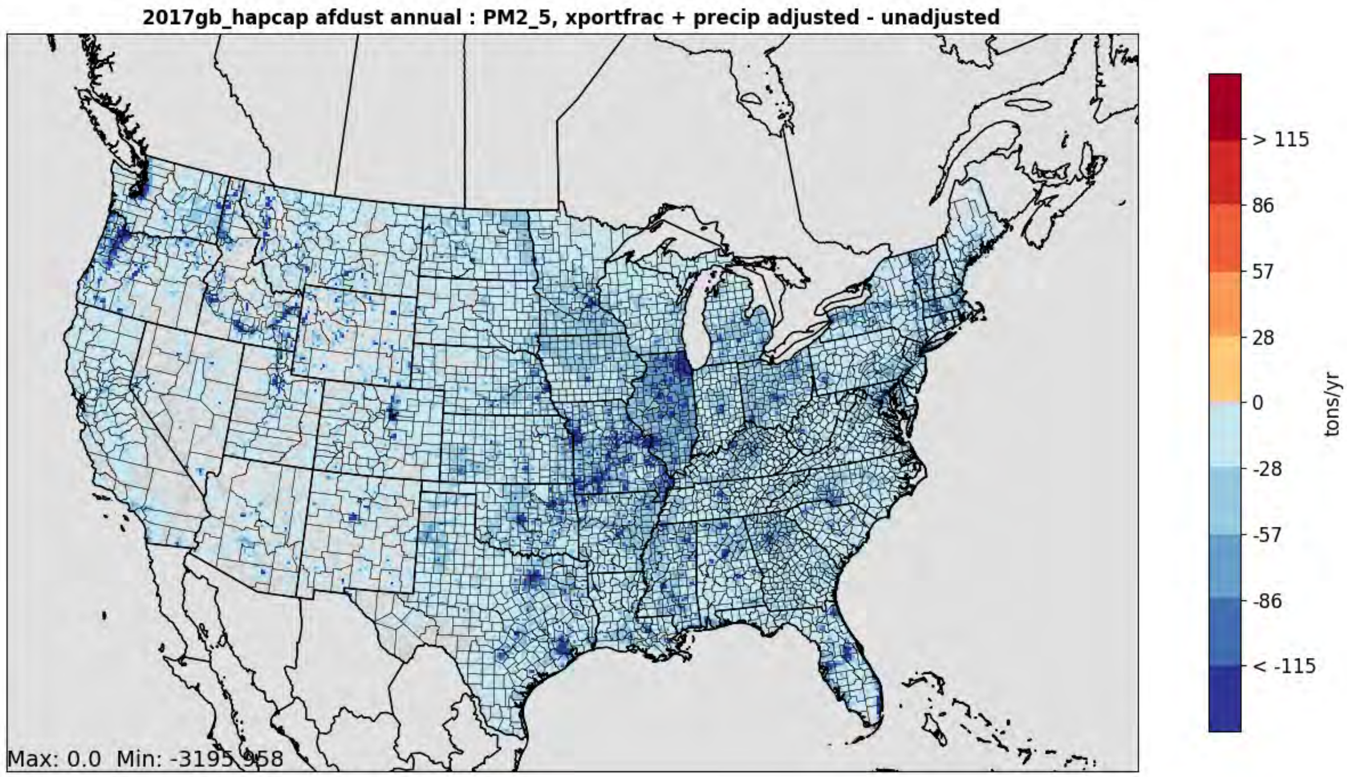
State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
California	308,755	39,031	-139,766	-17,141	45%	44%
Colorado	281,900	41,042	-141,886	-20,014	50%	49%
Connecticut	24,294	4,006	-19,271	-3,193	79%	80%
Delaware	15,439	2,389	-8,928	-1,387	58%	58%
District of Columbia	2,889	408	-1,710	-241	59%	59%
Florida	400,265	55,825	-228,186	-31,951	57%	57%
Georgia	297,192	42,391	-209,598	-29,711	71%	70%
Idaho	566,771	65,495	-326,528	-36,556	58%	56%
Illinois	1,111,225	159,957	-651,722	-93,185	59%	58%
Indiana	144,386	26,992	-93,202	-17,509	65%	65%
Iowa	388,258	57,032	-213,452	-31,290	55%	55%
Kansas	673,092	89,596	-301,317	-39,741	45%	44%
Kentucky	177,203	28,924	-128,645	-20,948	73%	72%
Louisiana	179,517	27,344	-117,168	-17,681	65%	65%
Maine	71,790	8,794	-61,563	-7,547	86%	86%
Maryland	74,608	11,975	-46,675	-7,512	63%	63%
Massachusetts	62,397	9,528	-49,509	-7,506	79%	79%
Michigan	296,244	38,935	-219,817	-28,620	74%	74%
Minnesota	426,434	59,889	-273,682	-37,804	64%	63%
Mississippi	452,433	55,232	-315,607	-38,169	70%	69%
Missouri	1,349,732	159,648	-859,469	-101,449	64%	64%
Montana	504,573	66,714	-291,508	-36,985	58%	55%
Nebraska	519,938	71,861	-237,323	-32,437	46%	45%
Nevada	139,660	18,453	-47,509	-6,254	34%	34%
New Hampshire	20,788	4,369	-17,840	-3,745	86%	86%
New Jersey	32,729	6,110	-22,004	-4,068	67%	67%
New Mexico	214,191	26,689	-84,194	-10,460	39%	39%
New York	236,016	33,300	-187,271	-26,287	79%	79%
North Carolina	237,441	32,066	-161,402	-21,829	68%	68%
North Dakota	391,394	60,485	-210,528	-32,057	54%	53%
Ohio	275,901	43,306	-190,273	-29,888	69%	69%
Oklahoma	607,313	82,670	-318,882	-42,469	53%	51%
Oregon	615,351	69,327	-430,557	-47,620	70%	69%
Pennsylvania	135,465	24,345	-99,228	-18,095	73%	74%
Rhode Island	4,662	781	-3,426	-574	73%	73%
South Carolina	120,214	16,666	-79,803	-11,128	66%	67%
South Dakota	215,704	38,411	-102,272	-18,006	47%	47%

State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
Tennessee	142,090	26,135	-99,696	-18,430	70%	71%
Texas	1,341,326	194,418	-636,491	-90,195	47%	46%
Utah	170,358	21,697	-87,785	-11,011	52%	51%
Vermont	77,400	8,614	-67,399	-7,478	87%	87%
Virginia	125,942	20,303	-89,914	-14,586	71%	72%
Washington	232,450	37,800	-138,429	-22,434	60%	59%
West Virginia	85,671	11,064	-72,688	-9,395	85%	85%
Wisconsin	183,820	31,237	-128,407	-21,796	70%	70%
Wyoming	547,211	61,352	-285,754	-31,623	52%	52%
Domain Total (12km CONUS)	**15,364,447**	**2,112,542**	**-9,051,028**	**-1,232,372**	**59%**	**58%**
Alaska	108,119	11,760	-99,193	-10,717	92%	91%
Hawaii	18,117	2,367	-9,740	-1,305	54%	55%
Puerto Rico	1,147,381	153,203	-1,129,242	-150,989	98%	99%
Virgin Islands	1,787	247	-891	-123	50%	50%

Figure 2-1 illustrates the impact of each step of the adjustment. The reductions due to the transport fraction adjustments alone are shown at the top of the figure. The reductions due to the precipitation adjustments alone are shown in the middle of the figure. The cumulative emission reductions after both transport fraction and meteorological adjustments are shown at the bottom of the figure. The top plot shows how the transport fraction has a larger reduction effect in the east, where forested areas are more effective at reducing PM transport than in many western areas. The middle plot shows how the meteorological impacts of precipitation, along with snow cover in the north, further reduce the dust emissions.

Figure 2-1. Impact of adjustments to fugitive dust emissions due to transport fraction, precipitation, and cumulative





2.2.2 Agricultural Livestock and Fertilizer (ag)

The livestock portion of the ag sector includes NH3 emissions from fertilizer and emissions of all pollutants other than $PM_{2.5}$ from livestock in the nonpoint (county-level) data category of the 2017NEI. $PM_{2.5}$ from livestock are in the Area Fugitive Dust (afdust) sector. Combustion emissions from agricultural equipment, such as tractors, are in the nonroad sector. The livestock emissions include VOC and HAP VOC in addition to NH3. $PM_{2.5}$ from livestock are in the afdust sector. The livestock SCCs included in the ag sector are shown in Table 2-6. The livestock SCCs are related to beef and dairy cattle, poultry production and waste, swine production, waste from horses and ponies, and production and waste for sheep, lambs, and goats.

Table 2-6. SCCs for the livestock sector

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805002000	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle production composite	Not Elsewhere Classified
2805007100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with dry manure management systems	Confinement
2805009100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - broilers	Confinement
2805010100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Confinement
2805018000	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle composite	Not Elsewhere Classified

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805025000	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production composite	Not Elsewhere Classified (see also 28-05-039, -047, -053)
2805035000	Miscellaneous Area Sources	Ag. Production - Livestock	Horses and Ponies Waste Emissions	Not Elsewhere Classified
2805040000	Miscellaneous Area Sources	Ag. Production - Livestock	Sheep and Lambs Waste Emissions	Total
2805045000	Miscellaneous Area Sources	Ag. Production - Livestock	Goats Waste Emissions	Not Elsewhere Classified

Agricultural livestock emissions in the platform are based on the 2017 NEI, which is a mix of state-submitted data and EPA estimates. Livestock emissions utilized improved animal population data. VOC livestock emissions, new for this sector, were estimated by multiplying a national VOC/NH_3 emissions ratio by the county NH_3 emissions. The 2017 NEI approach for livestock utilizes daily emission factors by animal and county from a model developed by Carnegie Mellon University (CMU) (Pinder, 2004, McQuilling, 2015) and 2017 U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) survey. Details on the approach are provided in Section 4.5 of the 2017 NEI TSD. Note that the "ag" sector does not include all of the livestock NH_3 emissions, as there is a very small amount of NH_3 emissions from livestock in the ptnonipm inventory (as point sources). In addition to NH_3, the "ag" sector also includes livestock emissions from all pollutants other than $PM_{2.5}$.

Fertilizer emissions

The "ag" sector includes all of the NH_3 emissions from fertilizer. As described in the 2017 NEI TSD, fertilizer emissions for 2017 are based on the FEST-C model (https://www.cmascenter.org/fest-c/). The bidirectional version of CMAQ (v5.3) and the Fertilizer Emissions Scenario Tool for CMAQ FEST-C (v1.3) were used to estimate ammonia (NH_3) emissions from agricultural soils. The approach to estimate year-specific fertilizer emissions consists of these steps:

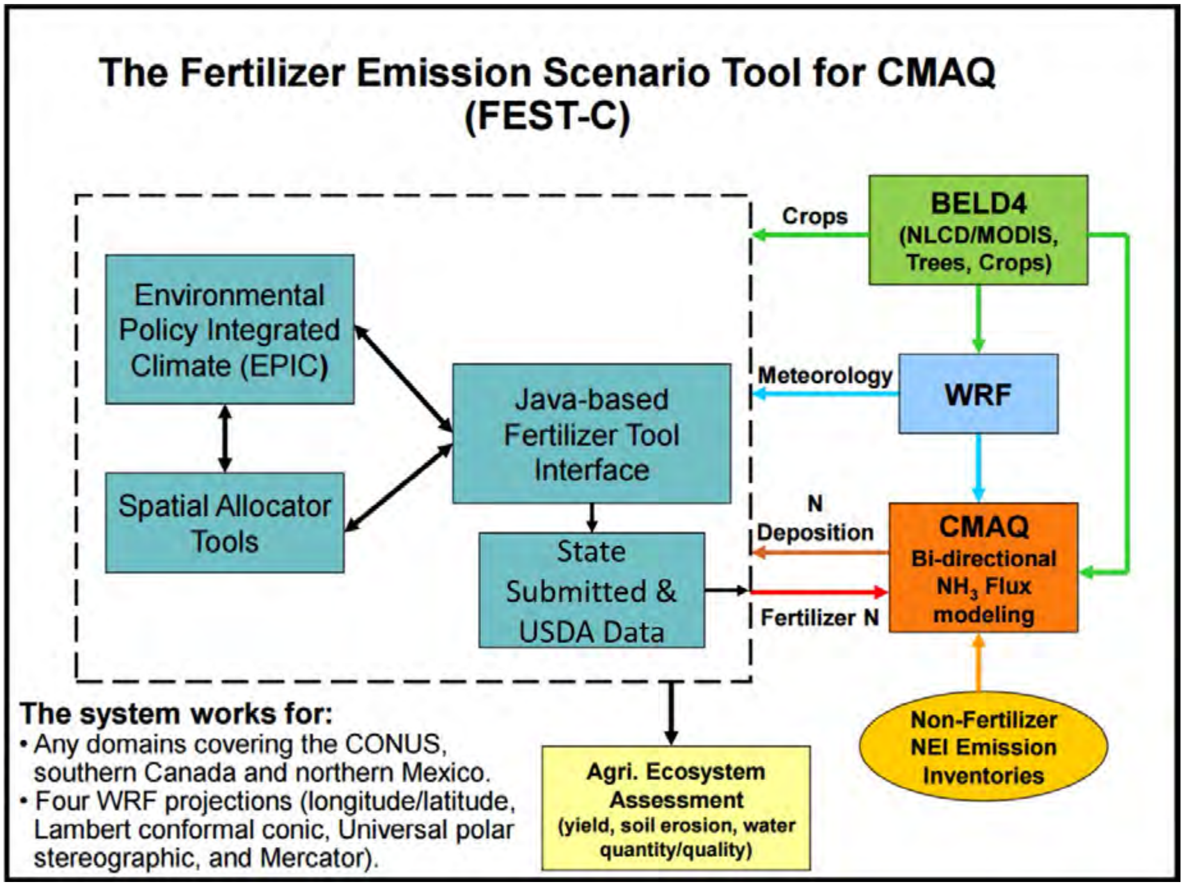
- Run FEST-C and CMAQ model with bidirectional ("bidi") NH_3 exchange to produce nitrate (NO_3), Ammonium (NH4+, including Urea), and organic (manure) nitrogen (N) fertilizer usage estimates, and gaseous ammonia NH_3 emission estimates respectively.
- Calculate county-level emission factors as the ratio of bidirectional CMAQ NH_3 fertilizer emissions to FEST-C total N fertilizer application.
- Assign the NH_3 emissions to one SCC: "…Miscellaneous Fertilizers" (2801700099).

FEST-C is the software program that processes land use and agricultural activity data to develop inputs for the CMAQ model when run with bidirectional exchange. FEST-C reads land use data from the Biogenic Emissions Landuse Dataset (BELD), meteorological variables from the Weather Research and Forecasting (WRF) model, and nitrogen deposition data from a previous or historical average CMAQ simulation. FEST-C, then uses the Environmental Policy Integrated Climate (EPIC) modeling system (https://epicapex.tamu.edu/epic/) to simulate the agricultural practices and soil biogeochemistry and provides information regarding fertilizer timing, composition, application method and amount.

An iterative calculation was applied to estimate fertilizer emissions. First, fertilizer application by crop type was estimated using FEST-C modeled data. Then CMAQ v5.3 was run with the Surface Tiled

Aerosol and Gaseous Exchange (STAGE) deposition option with bidirectional exchange to estimate fertilizer and biogenic NH3 emissions.

Figure 2-2. "Bidi" modeling system used to compute emissions from fertilizer application



Fertilizer Activity Data

The following activity parameters were input into the EPIC model:

- Grid cell meteorological variables from WRF
- Initial soil profiles/soil selection
- Presence of 21 major crops: irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g., lettuce, tomatoes, etc.)
- Fertilizer sales to establish the type/composition of nutrients applied
- Management scenarios for the 10 USDA production regions. These include irrigation, tile drainage, intervals between forage harvest, fertilizer application method (injected versus surface applied), and equipment commonly used in these production regions.

The WRF meteorological model was used to provide grid cell meteorological parameters for year 2017 using a national 12-km rectangular grid covering the continental U.S. The meteorological parameters in Table 2-7 were used as EPIC model inputs.

Table 2-7. Source of input variables for EPIC

EPIC input variable	Variable Source
Daily Total Radiation (MJ/m^2)	WRF
Daily Maximum 2-m Temperature (C)	WRF
Daily minimum 2-m temperature (C)	WRF
Daily Total Precipitation (mm)	WRF
Daily Average Relative Humidity (unitless)	WRF
Daily Average 10-m Wind Speed ($m\ s^{-1}$)	WRF
Daily Total Wet Deposition Oxidized N (g/ha)	CMAQ
Daily Total Wet Deposition Reduced N (g/ha)	CMAQ
Daily Total Dry Deposition Oxidized N (g/ha)	CMAQ
Daily Total Dry Deposition Reduced N (g/ha)	CMAQ
Daily Total Wet Deposition Organic N (g/ha)	CMAQ

Initial soil nutrient and pH conditions in EPIC were based on the 1992 USDA Soil Conservation Service (CSC) Soils-5 survey. The EPIC model then was run for 25 years using current fertilization and agricultural cropping techniques to estimate soil nutrient content and pH for the 2017 EPIC/WRF/CMAQ simulation.

The presence of crops in each model grid cell was determined using USDA Census of Agriculture data (2012) and USGS National Land Cover data (2011). These two data sources were used to compute the fraction of agricultural land in a model grid cell and the mix of crops grown on that land.

Fertilizer sales data and the 6-month period in which they were sold were extracted from the 2014 Association of American Plant Food Control Officials (AAPFCO, http://www.aapfco.org/publications.html). AAPFCO data were used to identify the composition (e.g., urea, nitrate, organic) of the fertilizer used, and the amount applied is estimated using the modeled crop demand. These data were useful in making a reasonable assignment of what kind of fertilizer is being applied to which crops.

Management activity data refers to data used to estimate representative crop management schemes. The USDA Agricultural Resource Management Survey (ARMS, https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Ag_Resource_Management/) was used to provide management activity data. These data cover 10 USDA production regions and provide management schemes for irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g., lettuce, tomatoes, etc.).

For livestock and fertilizer, meteorological-based temporalization (described in Section 3.3.5) is used for month-to-day and day-to-hour temporalization. Monthly profiles for livestock are based on the daily data underlying the EPA estimates from the development of the 2014 NEI Version 2 (2014NEIv2). The fertilizer inventory includes monthly emissions from FEST-C and uses the same meteorological-based month-to-hour profiles as livestock in the same way as was done for other recent platforms.

2.2.3 Nonpoint Oil and Gas Sector (np_oilgas)

The nonpoint oil and gas (np_oilgas) sector includes oil and gas exploration and production sources, both onshore and offshore (state-owned only). The EPA estimated emissions for all counties with 2017 oil and gas activity data with the Oil and Gas Tool, and many S/L/T agencies also submitted nonpoint oil and gas data. Where S/L/T submitted nonpoint CAPs but no HAPs, the EPA augmented the HAPs using HAP augmentation factors (county and SCC level) created from the Oil and Gas Tool. The types of sources covered include drill rigs, workover rigs, artificial lift, hydraulic fracturing engines, pneumatic pumps and other devices, storage tanks, flares, truck loading, compressor engines, and dehydrators. Because of the importance of emissions from this sector, special consideration is given to the speciation, spatial allocation, and monthly temporalization of nonpoint oil and gas emissions, instead of relying on older, more generalized profiles.

EPA Oil and Gas Tool

EPA updated the Nonpoint Oil and Gas Emission Estimation Tool (i.e., the "tool") to estimate emissions for 2017. Year 2017 oil and gas activity data was supplied to EPA by state air agencies and where state data is not supplied to EPA, EPA populates the 2017 inventory with the best available data. The tool is an Access database that utilizes county-level activity data (e.g., oil production and well counts), operational characteristics (types and sizes of equipment), and emission factors to estimate emissions. The tool creates a CSV-formatted emissions dataset covering all national nonpoint oil and gas emissions. This dataset is then converted to FF10 format for use in SMOKE modeling. This 2017 NEI Tool document can be found at: https://gaftp.epa.gov/air/nei/2017/doc/supporting_data/nonpoint/. More details on the inputs for and running of the tool for 2017 are provided in the 2017 NEI TSD.

2.2.4 Residential Wood Combustion (rwc)

The residential wood combustion (rwc) sector includes residential wood burning devices such as fireplaces, fireplaces with inserts (inserts), free standing woodstoves, pellet stoves, outdoor hydronic heaters (also known as outdoor wood boilers), indoor furnaces, and outdoor burning in firepots and chimeneas. Free standing woodstoves and inserts are further differentiated into three categories: 1) conventional (not EPA certified); 2) EPA certified, catalytic; and 3) EPA certified, noncatalytic. Generally speaking, the conventional units were constructed prior to 1988. Units constructed after 1988 have to meet EPA emission standards and they are either catalytic or non-catalytic. As with the other nonpoint categories, a mix of S/L and EPA estimates were used. The EPA's estimates use updated methodologies for activity data and some changes to emission factors. The source classification codes (SCCs) in the RWC sector are listed in Table 2-8.

Some improvements to RWC emissions estimates were made for the 2017 NEI and were included in this study. The EPA, along with the Commission on Environmental Cooperation (CEC), the Northeast States for Coordinated Air Use Management (NESCAUM), and Abt Associates, conducted a national survey of wood-burning activity in 2018. The results of this survey were used to estimate county-level burning activity data. The activity data for RWC processes is the amount of wood burned in each county, which is based on data from the CEC survey on the fraction of homes in each county that use each wood-burning appliance and the average amount of wood burned in each appliance. These assumptions are used with the number of occupied homes in each county to estimate the total amount of wood burned in each county, in cords for cordwood appliances and tons for pellet appliances. Cords of wood are converted to tons using county-level density factors from the U.S. Forest Service. RWC emissions were calculated by multiplying the tons of wood burned by emissions factors. For more information on the development of the residential wood combustion emissions, see Section 4.15 of the 2017 NEI TSD

Table 2-8. SCCs for the residential wood combustion sector

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2104008100	Stationary Source Fuel Combustion	Residential	Wood	Fireplace: general
2104008210	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; non-EPA certified
2104008220	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; EPA certified; non-catalytic
2104008230	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; EPA certified; catalytic
2104008300	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, general
2104008310	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, non-EPA certified
2104008320	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, EPA certified, non-catalytic
2104008330	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, EPA certified, catalytic
2104008400	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: pellet-fired, general (freestanding or FP insert)
2104008510	Stationary Source Fuel Combustion	Residential	Wood	Furnace: Indoor, cordwood-fired, non-EPA certified
2104008530	Stationary Source Fuel Combustion	Residential	Wood	Furnace: Indoor, pellet-fired, general
2104008610	Stationary Source Fuel Combustion	Residential	Wood	Hydronic heater: outdoor
2104008620	Stationary Source Fuel Combustion	Residential	Wood	Hydronic heater: indoor
2104008630	Stationary Source Fuel Combustion	Residential	Wood	Hydronic heater: pellet-fired
2104008700	Stationary Source Fuel Combustion	Residential	Wood	Outdoor wood burning device, NEC (fire-pits, chimeneas, etc)
2104009000	Stationary Source Fuel Combustion	Residential	Firelog	Total: All Combustor Types

2.2.5 Nonpoint (nonpt)

Stationary nonpoint sources that were not subdivided into the afdust, ag, np_oilgas, or rwc sectors were assigned to the "nonpt" sector. Locomotives and CMV mobile sources from the 2017 NEI nonpoint inventory are described with the mobile sources. The types of sources in the nonpt sector include:

- stationary source fuel combustion, including industrial, commercial, and residential and orchard heaters;

- chemical manufacturing;
- industrial processes such as commercial cooking, metal production, mineral processes, petroleum refining, wood products, fabricated metals, and refrigeration;
- solvent utilization for surface coatings such as architectural coatings, auto refinishing, traffic marking, textile production, furniture finishing, and coating of paper, plastic, metal, appliances, and motor vehicles;
- solvent utilization for degreasing of furniture, metals, auto repair, electronics, and manufacturing;
- solvent utilization for dry cleaning, graphic arts, plastics, industrial processes, personal care products, household products, adhesives and sealants;
- solvent utilization for asphalt application, roofing, and pesticide application;
- storage and transport of petroleum for uses such as portable gas cans, bulk terminals, gasoline service stations, aviation, and marine vessels;
- storage and transport of chemicals;
- waste disposal, treatment, and recovery via incineration, open burning, landfills, and composting; and
- miscellaneous area sources such as cremation, hospitals, lamp breakage, and automotive repair shops.

The nonpt sector includes emission estimates for Portable Fuel Containers (PFCs), also known as "gas cans." The PFC inventory consists of five distinct sources of PFC emissions, further distinguished by residential or commercial use. The five sources are: (1) displacement of the vapor within the can; (2) spillage of gasoline while filling the can; (3) spillage of gasoline during transport; (4) emissions due to evaporation (i.e., diurnal emissions); and (5) emissions due to permeation. Note that spillage and vapor displacement associated with using PFCs to refuel nonroad equipment are included in the nonroad inventory.

2.3 Onroad Mobile sources (onroad)

Onroad mobile source include emissions from motorized vehicles operating on public roadways. These include passenger cars, motorcycles, minivans, sport-utility vehicles, light-duty trucks, heavy-duty trucks, and buses. The sources are further divided by the fuel they use, including diesel, gasoline, E-85, and compressed natural gas (CNG) vehicles. The sector characterizes emissions from parked vehicle processes (e.g., starts, hot soak, and extended idle) as well as from on-network processes (i.e., from vehicles as they move along the roads). For more details on the approach and for a summary of the MOVES inputs submitted by states, see section 6.5.1 of the 2017 NEI TSD. In addition, a number of states submitted 2017-specific activity data for incorporation into this platform.

Except for California, all onroad emissions are generated using the SMOKE-MOVES emissions modeling framework that leverages MOVES-generated emission factors https://www.epa.gov/moves), county and SCC-specific activity data, and hourly meteorological data. Specifically, EPA used MOVES inputs for representative counties, vehicle miles traveled (VMT), vehicle population (VPOP), and hoteling hours data for all counties, along with tools that integrated the MOVES model with SMOKE. In this way, it was possible to take advantage of the gridded hourly temperature data available from meteorological modeling that are also used for air quality modeling. The onroad source classification codes (SCCs) in the modeling platform are more finely resolved than those in the National Emissions Inventory (NEI). The

NEI SCCs distinguish vehicles and fuels. The SCCs used in the model platform also distinguish between emissions processes (i.e., off-network, on-network, and extended idle), and road types.

2.3.1 Inventory Development using SMOKE-MOVES

Onroad emissions were computed with SMOKE-MOVES by multiplying specific types of vehicle activity data by the appropriate emission factors. This section includes discussions of the activity data and the emission factor development. The vehicles (aka source types) for which MOVES computes emissions are shown in Table 2-9. SMOKE-MOVES was run for specific modeling grids. Emissions for the contiguous U.S. states and Washington, D.C., were computed for a grid covering those areas. Emissions for Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands were computed by running SMOKE-MOVES for distinct grids covering each of those regions and are included in the onroad_nonconus sector. In some summary reports these non-CONUS emissions are aggregated with emissions from the onroad sector.

Table 2-9. MOVES vehicle (source) types

MOVES vehicle type	Description	HPMS vehicle type
11	Motorcycle	10
21	Passenger Car	25
31	Passenger Truck	25
32	Light Commercial Truck	25
41	Intercity Bus	40
42	Transit Bus	40
43	School Bus	40
51	Refuse Truck	50
52	Single Unit Short-haul Truck	50
53	Single Unit Long-haul Truck	50
54	Motor Home	50
61	Combination Short-haul Truck	60
62	Combination Long-haul Truck	60

SMOKE-MOVES makes use of emission rate “lookup” tables generated by MOVES that differentiate emissions by process (i.e., running, start, vapor venting, etc.), vehicle type, road type, temperature, speed, hour of day, etc. To generate the MOVES emission rates that could be applied across the U.S., EPA used an automated process to run MOVES to produce year 2017-specific emission factors by temperature and speed for a series of “representative counties,” to which every other county was mapped. The representative counties for which emission factors are generated are selected according to their state, elevation, fuels, age distribution, ramp fraction, and inspection and maintenance programs. Each county is then mapped to a representative county based on its similarity to the representative county with respect to those attributes. For this study, there are 296 representative counties in the continental U.S. A detailed discussion of the representative counties is in the 2017 NEI TSD, Section 6.8.2.

Once representative counties have been identified, emission factors are generated with MOVES for each representative county and for two “fuel months” – January to represent winter months, and July to represent summer months – due to the different types of fuels used. SMOKE selects the appropriate MOVES emissions rates for each county, hourly temperature, SCC, and speed bin and then multiplies the emission rate by appropriate activity data. For on-roadway emissions, vehicle miles travelled (VMT) is the activity data, vehicle population (VPOP) is used for many off-network processes, and hoteling hours are used to develop emissions for extended idling of combination long-haul trucks. These calculations are done for every county and grid cell in the continental U.S. for each hour of the year.

The SMOKE-MOVES process for creating the model-ready emissions consists of the following steps:

1) Determine which counties will be used to represent other counties in the MOVES runs.
2) Determine which months will be used to represent other month's fuel characteristics.
3) Create inputs needed only by MOVES. MOVES requires county-specific information on vehicle populations, age distributions, and inspection-maintenance programs for each of the representative counties.
4) Create inputs needed both by MOVES and by SMOKE, including temperatures and activity data.
5) Run MOVES to create emission factor tables for the temperatures found in each county.
6) Run SMOKE to apply the emission factors to activity data (VMT, VPOP, and HOTELING) to calculate emissions based on the gridded hourly temperatures in the meteorological data.
7) Aggregate the results to the county-SCC level for summaries and quality assurance.

The onroad emissions are processed in four processing streams that are merged together into the onroad sector emissions after each of the four streams have been processed:

- rate-per-distance (RPD) uses VMT as the activity data plus speed and speed profile information to compute on-network emissions from exhaust, evaporative, permeation, refueling, and brake and tire wear processes;
- rate-per-vehicle (RPV) uses VPOP activity data to compute off-network emissions from exhaust, evaporative, permeation, and refueling processes;
- rate-per-profile (RPP) uses VPOP activity data to compute off-network emissions from evaporative fuel vapor venting, including hot soak (immediately after a trip) and diurnal (vehicle parked for a long period) emissions; and
- rate-per-hour (RPH) uses hoteling hours activity data to compute off-network emissions for idling of long-haul trucks from extended idling and auxiliary power unit process.

The onroad emissions inputs for the platform are based on the 2017 NEI, described in more detail in Section 6 of the 2017 NEI TSD. These inputs include:

- MOVES County databases (CDBs) including Low Emission Vehicle (LEV) table
- Representative counties
- Fuel months
- Meteorology
- Activity data (VMT, VPOP, speed, HOTELING)

Representative counties, fuel months and other inputs were consistent with those in the 2017 NEI. States that submitted activity data and development of the EPA default activity data sets for VMT, VPOP, and hoteling hours are described in detail in the 2017 NEI TSD and supporting documents. Hoteling hours activity are used to calculate emissions from extended idling and auxiliary power units (APUs) by combination long-haul trucks.

2.3.2 Onroad Activity Data Development

SMOKE-MOVES uses vehicle miles traveled (VMT), vehicle population (VPOP), and hours of hoteling, to calculate emissions. These datasets are collectively known as “activity data”. For each of these activity datasets, first a national dataset was developed; this national dataset is called the “EPA default” dataset. The default dataset started with the 2017 NEI activity data, which was supplemented with data submitted by state and local agencies. EPA default activity was used for California, but the emissions were scaled to California-supplied values during the emissions processing.

Vehicle Miles Traveled (VMT) and Vehicle Population (VPOP)

Representative counties, fuel months and other inputs were consistent with those in the 2017 NEI. States that submitted activity data and development of the EPA default activity data sets for VMT, VPOP, and hoteling hours are described in detail in the 2017 NEI TSD (EPA, 2021) and supporting documents.

Speed Activity (SPEED/SPDIST)

In SMOKE 4.7, SMOKE-MOVES was updated to use speed distributions similarly to how they are used when running MOVES in inventory mode. This new speed distribution file, called SPDIST, specifies the amount of time spent in each MOVES speed bin for each county, vehicle (aka source) type, road type, weekday/weekend, and hour of day. This file contains the same information at the same resolution as the Speed Distribution table used by MOVES but is reformatted for SMOKE. Using the SPDIST file results in a SMOKE emissions calculation that is more consistent with MOVES than the old hourly speed profile (SPDPRO) approach, because emission factors from all speed bins can be used, rather than interpolating between the two bins surrounding the single average speed value for each hour as is done with the SPDPRO approach.

As was the case with the previous SPDPRO approach, the SPEED inventory that includes a single overall average speed for each county, SCC, and month, must still be read in by the SMOKE program Smkinven. SMOKE requires the SPEED dataset to exist even when speed distribution data are available, even though only the speed distribution data affects the selection of emission factors. The SPEED and SPDIST for 2017NEI are based on a combination of the CRC A-100 (CRC, 2017) project data and 2017 NEI MOVES CDBs.

Hoteling Hours (HOTELING)

Hoteling hours were capped by county at a theoretical maximum and any excess hours of the maximum were reduced. For calculating reductions, a dataset of truck stop parking space availability was used, which includes a total number of parking spaces per county. This same dataset is used to develop the spatial surrogate for allocating county-total hoteling emissions to model grid cells. The parking space dataset includes several recent updates based on new truck stops opening and other new information. There are 8,760 hours in the year 2017; therefore, the maximum number of possible hoteling hours in a particular county is equal to 8,760 * the number of parking spaces in that county. Hoteling hours were capped at that theoretical maximum value for 2017 in all counties, with some exceptions.

Because the truck stop parking space dataset may be incomplete in some areas, and trucks may sometimes idle in areas other than designated spaces, it was assumed that every county has at least 12 parking spaces, even if fewer parking spaces are found in the parking space dataset. Therefore, hoteling hours are never reduced below 105,408 hours for the year in any county. If the unreduced hoteling hours were already below that maximum, the hours were left unchanged; in other words, hoteling activity are never increased as a result of this analysis. Four states requested that no reductions be applied to the hoteling activity based on parking space availability: CO, ME, NJ, and NY. For these states, reductions based on parking space availability were not applied.

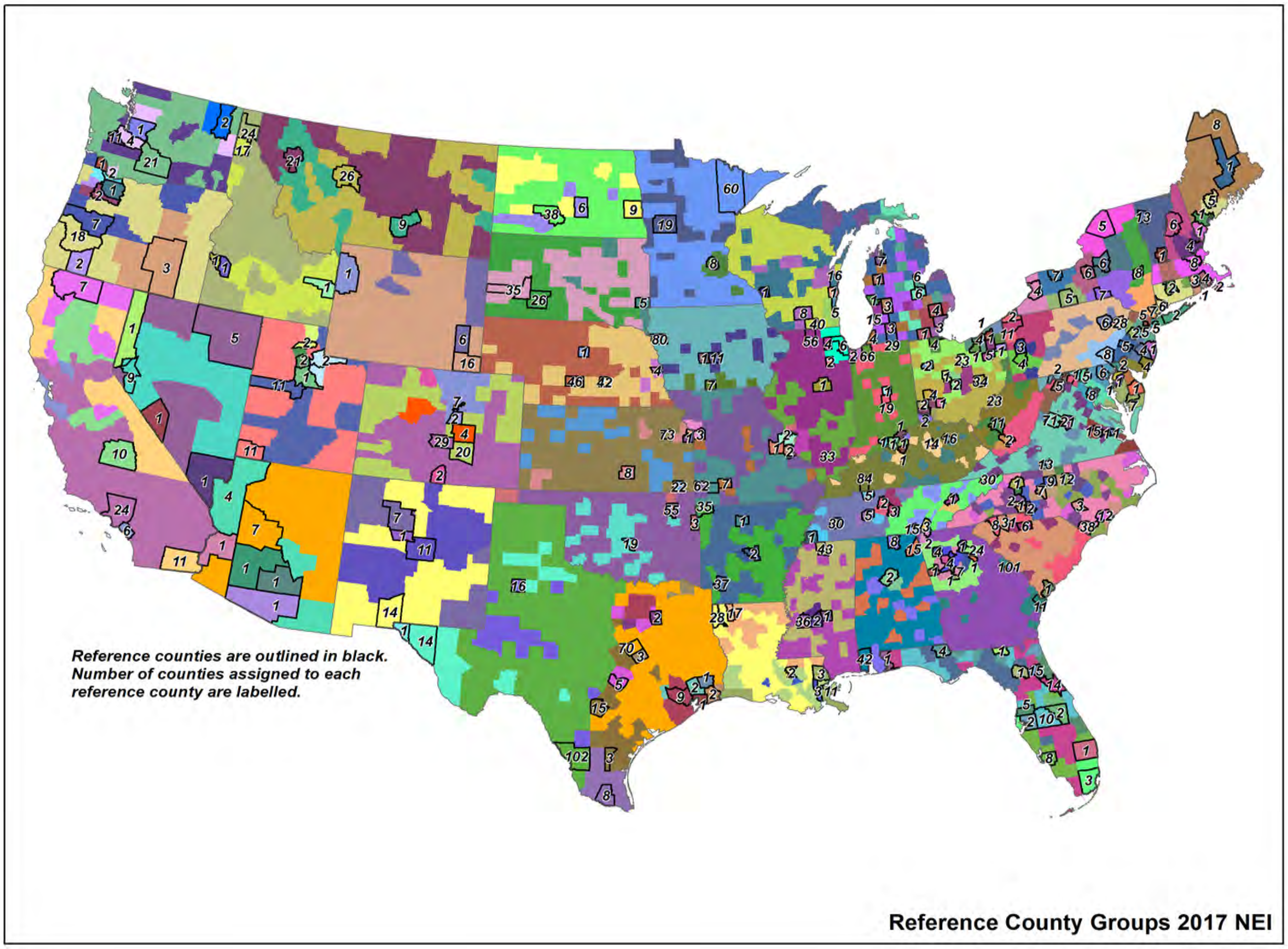
The final step related to hoteling activity is to split county totals into separate values for extended idling (SCC 2202620153) and Auxiliary Power Units (APUs) (SCC 2202620191). New Jersey's submittal of hoteling activity specified a 30% APU split, and this was used throughout NJ. For the rest of the country, a 12.4% APU split was used, meaning that during 12.4% of the hoteling hours auxiliary power units are assumed to be running.

2.3.3 MOVES Emission Factor Table Development

MOVES2014b was run in emission rate mode to create emission factor tables using CB6 speciation for 2017, for all representative counties and fuel months. MOVES was run for all counties in Alaska, Hawaii, and Virgin Islands, and for a single representative county in Puerto Rico.

The county databases CDBs used to run MOVES to develop the emission factor tables were those used for the 2017 NEI and therefore included any updated data provided and accepted for the 2017 NEI process. The 2017 NEI development included an extensive review of the various tables including speed distributions were performed. Where state speed profiles, speed distributions. and temporal profiles data were not accepted from S/L submissions, those data were obtained from the CRC A-100 study. Each county in the continental U.S. was classified according to its state, altitude (high or low), fuel region, the presence of inspection and maintenance programs, the mean light-duty age, and the fraction of ramps. A binning algorithm was executed to identify "like counties", and then specific requests for representative county groups by states for the 2017 NEI were honored. The result was 296 representative counties for CONUS and 38 for Alaska, Hawaii, Puerto Rico, and the US Virgin Islands, as shown in Figure 2-3.

Figure 2-3. Representative Counties in 2017



Age distributions are a key input to MOVES in determining emission rates. The age distributions for 2017 were updated based on vehicle registration data obtained from the CRC A-115 project (CRC, 2019), subject to reductions for older vehicles determined according to CRC A-115 methods but using additional age distribution data that became available as part of the 2017 NEI submitted input data. One of the findings of CRC project A-115 is that IHS data contain higher vehicle populations than state agency analyses of the same Department of Motor Vehicles data, and the discrepancies tend to increase with increasing vehicle age (i.e., there are more older vehicles in the IHS data). The CRC project dealt with the discrepancy by releasing datasets based on raw (unadjusted) information and adjusted sets of age distributions, where the adjustments reflected the differences in population by model year of 2014 IHS data and 2014 submitted data from a single state.

For the 2017 NEI, EPA repeated the CRC's assessment of IHS vs. state vehicles by age, but with updated information from the 2017 NEI and for more states. The 2017 light-duty vehicle (LDV) populations from the CRC A-115 project were compared by model year to the populations submitted by state/local (S/L) agencies for the 2017 NEI. The comparisons by model year were used to develop adjustment factors that remove older age LDVs from the IHS dataset. Out of 31 S/L agencies that provided age distribution and vehicle population data for the 2017 NEI, sixteen agencies provided LDV population and age distributions with snapshot dates of January 2017, July 2017, or 2018. The other fifteen agencies had either unknown or older (back to 2013) data pull dates, so were compared to the 2017 IHS data. The vehicle populations by model year were compared with IHS data for each of the sixteen agencies for source type 21 (passenger cars) and for source type 31 plus 32 (light trucks) together. Prior to finalizing the activity data, the S/L agency populations of source type 21 and light trucks to match IHS car and light-duty truck splits by county so that vehicles of the same model and year were consistently classified into MOVES source types throughout the country. The IHS population of vehicles were found to be higher than the pooled state data by 6.5 percent for cars and 5.9 percent for light trucks.

To adjust for the additional vehicles in the IHS data, vehicle age distribution adjustment factors as one minus the fraction of vehicles to remove from IHS to equal the state data, with two exceptions: (1) the model year range 2006/2007 to 2017 receives no adjustment and (2) the model year 1987 receives a capped adjustment that equals the adjustment to 1988. Table 2-10 below shows the fraction of vehicles to keep by model year based on this analysis. The adjustments were applied to the 2017 IHS-based age distributions from CRC project A-115 prior to use in this 2017 platform. In addition, the age distributions to ensure the "tail" of the distribution corresponding to age 30 years and older vehicles did not exceed 20% of the fleet. After limiting the age distribution tails, the age distributions were renormalized to ensure they summed to one (1). In addition, antique license plate vehicles were removed based on the registration summary from IHS. Nationally, the prevalence of antique plates is only 0.8 percent, but as high as 6 percent in some states (e.g., Mississippi).

Table 2-10. Fraction of IHS Vehicle Populations to Retain for 2017 NEI

Model Year	Cars	Light
pre-1989	0.675	0.769
1989	0.730	0.801
1990	0.732	0.839
1991	0.740	0.868
1992	0.742	0.867
1993	0.763	0.867
1994	0.787	0.842
1995	0.776	0.865
1996	0.790	0.881
1997	0.808	0.871
1998	0.819	0.870
1999	0.840	0.874
2000	0.838	0.896
2001	0.839	0.925
2002	0.864	0.921
2003	0.887	0.942
2004	0.926	0.953
2005	0.941	0.966
2006	1	0.987
2007-2017	1	1

In addition to removing the older and antique plate vehicles from the IHS data, 25 counties found to be outliers because their fleet age was significantly younger than in typical counties. The outlier review was limited to LDV source types 21, 31, and 32. Many rural counties have outliers for low-population source types such as Transit Bus and Refuse Truck due to small sample sizes, but these do not have much of an impact on the inventory overall and reflect sparse data in low-population areas and therefore do not require correction.

The most extreme examples of LDV outliers were Light Commercial Truck age distributions where over 50 percent of the population in the entire county is 0 and 1 years old. These sorts of young fleets can happen if the headquarters of a leasing or rental company is the owner/entity of a relatively large number of vehicles relative to the county-wide population. While the business owner of thousands of new vehicles may reside in a single county, the vehicles likely operate in broader areas without being registered where they drive. To avoid creating artificial low spots of LDV emissions in these outlier counties, data for all counties with more than 35% new vehicles were excluded from the final set of grouped age distributions that went into the CDBs.

The final age distributions were then grouped using a population-weighted average of the source type populations of each county in the representative county group. The resulting end-product was age distributions for each of the 13 source types in each of the representative counties for 2017. The long-haul truck source types 53 (Single Unit) and 62 (Combination Unit) are based on a nationwide average due to the long-haul nature of their operation.

To create the emission factors, MOVES was run separately for each representative county and fuel month and for each temperature bin needed for calendar year 2017. The CDBs used to run MOVES include the state-specific control measures such as the California low emission vehicle (LEV) program, except that fuels were updated to represent calendar year 2017. In addition, the range of temperatures run along with the average humidities used were specific to the year 2017. The MOVES results were post-processed into CSV-formatted emission factor tables that can be read by SMOKE-MOVES.

2.3.4 Onroad California Inventory Development (onroad_ca)

California is the only state agency for which submitted onroad emissions were used in the 2017 NEI and this study. California uses their own emission model, EMFAC, which uses emission inventory codes (EICs) to characterize the emission processes instead of SCCs. The EPA and California worked together to develop a code mapping to better match EMFAC's EICs to EPA MOVES' detailed set of SCCs that distinguish between off-network and on-network and brake and tire wear emissions. This detail is needed for modeling but not for the NEI. California provided their CAP and HAP emissions by county using EPA SCCs after applying an agreed-to EIC to SCC mapping. California provided EMFAC2017-based onroad emissions inventories for 2017 that were used for this study. To preserve MOVES speciation in California, VOC HAP emissions provided by California were not used in modeling; instead, HAP-to-VOC ratios based on MOVES speciation were used in combination with California-provided VOC emissions to estimate new VOC HAP emissions. Emissions for other HAPs, including metals and PAHs, were used as provided by California.

The California onroad mobile source emissions were created through a hybrid approach of combining state-supplied annual emissions with EPA-developed SMOKE-MOVES runs. Through this approach, the platform was able to reflect the unique rules in California, while leveraging the more detailed SCCs and the highly resolved spatial patterns, temporal patterns, and speciation from SMOKE-MOVES. The basic steps involved in temporally allocating onroad emissions from California based on SMOKE-MOVES results were:

1) Run CA using EPA inputs through SMOKE-MOVES to produce hourly emissions hereafter known as "EPA estimates." These EPA estimates for CA are run in a separate sector called "onroad_ca."

2) Calculate ratios between state-supplied emissions and EPA estimates. The ratios were calculated for each county/SCC/pollutant combination based on the California onroad emissions inventory. Unlike in previous platforms, the California data separated off and on-network emissions and extended idling. However, the on-network did not provide specific road types, and California's emissions did not include information for vehicles fueled by E-85, so these differentiations were obtained using MOVES.
3) Create an adjustment factor file (CFPRO) that includes EPA-to-state estimate ratios.
4) Rerun CA through SMOKE-MOVES using EPA inputs and the new adjustment factor file.

Through this process, adjusted model-ready files were created that sum to annual totals from California, but have the temporal and spatial patterns reflecting the highly resolved meteorology and SMOKE-MOVES. After adjusting the emissions, this sector is called "onroad_ca_adj." Note that in emission summaries, the emissions from the "onroad" and "onroad_ca_adj" sectors are summed and designated as the emissions for the onroad sector.

2.4 Nonroad Mobile sources (cmv, rail, nonroad)

The nonroad mobile source emission modeling sectors consist of nonroad equipment emissions (nonroad), locomotive (rail), and CMV emissions.

2.4.1 Category 1, Category 2 Commercial Marine Vessels (cmv_c1c2)

The cmv_c1c2 sector contains Category 1 and 2 CMV emissions from the 2017 NEI. Category 1 and 2 vessels use diesel fuel. All emissions in this sector are annual and at county-SCC resolution; however, in the NEI they are provided at the sub-county level (port or underway shape ids) and by SCC and emission type (e.g., hoteling, maneuvering). This sub-county data in the NEI are used to create spatial surrogates. For more information on CMV sources in the 2017 NEI, see Section 4.21 of the 2017 NEI TSD. C1 and C2 emissions that occur outside of state waters are not assigned to states. All CMV emissions in the cmv_c1c2 sector are treated as hourly gridded point sources with stack parameters that should result in them being placed in layer 1.

Sulfur dioxide (SO_2) emissions reflect rules that reduced sulfur emissions for CMV that took effect in the year 2015. The cmv_c1c2 inventory sector contains small to medium-size engine CMV emissions. Category 1 and Category 2 (C1C2) marine diesel engines typically range in size from about 700 to 11,000 hp. These engines are used to provide propulsion power on many kinds of vessels including tugboats, towboats, supply vessels, fishing vessels, and other commercial vessels in and around ports. They are also used as stand-alone generators for auxiliary electrical power on many types of vessels. Category 1 represents engines up to 7 liters per cylinder displacement. Category 2 includes engines from 7 to 30 liters per cylinder.

The cmv_c1c2 inventory sector contains sources that traverse state and federal waters along with emissions from surrounding areas of Canada, Mexico, and international waters. The cmv_c1c2 sources are modeled as point sources but using plume rise parameters that cause the emissions to be released in the ground layer of the air quality model.

The cmv_c1c2 sources within state waters are identified in the inventory with the Federal Information Processing Standard (FIPS) county code for the state and county in which the vessel is registered. The cmv_c1c2 sources that operate outside of state waters but within the Emissions Control Area (ECA) are encoded with a state FIPS code of 85. The ECA areas include parts of the Gulf of Mexico, and parts of the Atlantic and Pacific coasts. The cmv_c1c2 sources in the 2017 inventory are categorized as operating either in-port or underway and as main and auxiliary engines are encoded using the SCCs listed in Table 2-11.

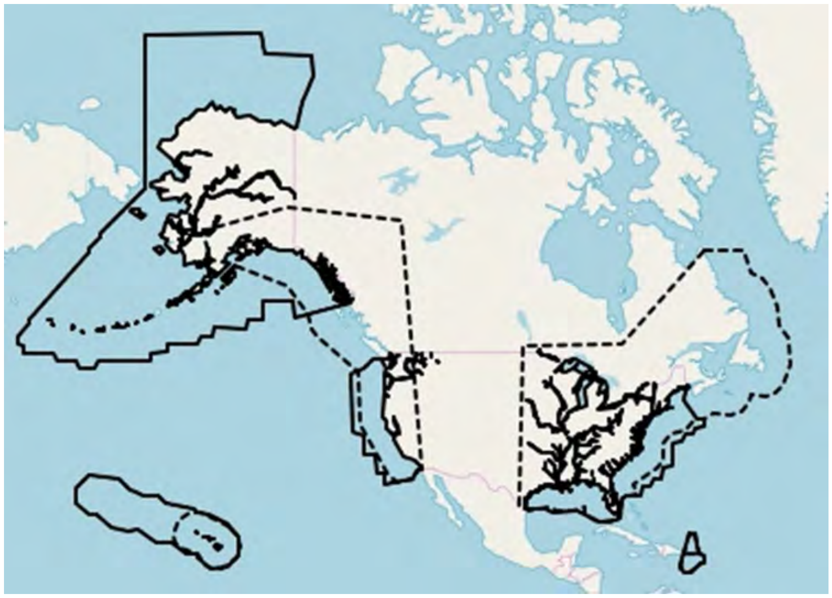
Table 2-11. SCCs for cmv_c1c2 sector

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2280002101	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Port emissions: Main Engine
2280002102	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Port emissions: Auxiliary Engine
2280002201	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Underway emissions: Main Engine
2280002202	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Underway emissions: Auxiliary Engine

Category 1 and 2 CMV emissions were developed for the 2017 NEI,[3] The 2017 NEI emissions were developed based signals from Automated Identification System (AIS) transmitters. AIS is a tracking system used by vessels to enhance navigation and avoid collision with other AIS transmitting vessels. The USEPA Office of Transportation and Air Quality received AIS data from the U.S. Coast Guard (USCG) to quantify all ship activity which occurred between January 1 and December 31, 2017. The provided AIS data extends beyond 200 nautical miles from the U.S. coast (Figure 2-4). This boundary is roughly equivalent to the border of the U.S Exclusive Economic Zone and the North American ECA, although some non-ECA activity are captured as well.

[3] Category 1 and 2 Commercial Marine Vessel 2017 Emissions Inventory (ERG, 2019).

Figure 2-4. 2017NEI geographical extent (solid) and U.S. ECA (dashed)



The AIS data were compiled into five-minute intervals by the USCG, providing a reasonably refined assessment of a vessel's movement. For example, using a five-minute average, a vessel traveling at 25 knots would be captured every two nautical miles that the vessel travels. For slower moving vessels, the distance between transmissions would be less. The ability to track vessel movements through AIS data and link them to attribute data, has allowed for the development of an inventory of very accurate emission estimates. These AIS data were used to define the locations of individual vessel movements, estimate hours of operation, and quantify propulsion engine loads. The compiled AIS data also included the vessel's International Marine Organization (IMO) number and Maritime Mobile Service Identifier (MMSI); which allowed each vessel to be matched to their characteristics obtained from the Clarksons ship registry (Clarksons, 2018).

USEPA used the engine bore and stroke data to calculate cylinder volume. Any vessel that had a calculated cylinder volume greater than 30 liters was incorporated into the USEPA's new Category 3 Commercial Marine Vessel (C3CMV) model. The remaining records were assumed to represent Category 1 and 2 (C1C2) or non-ship activity. The C1C2 AIS data were quality assured including the removal of duplicate messages, signals from pleasure craft, and signals that were not from CMV vessels (e.g., buoys, helicopters, and vessels that are not self-propelled). Following this, there were 422 million records remaining.

The emissions were calculated for each time interval between consecutive AIS messages for each vessel and allocated to the location of the message following to the interval. Emissions were calculated according to Equation 2-1.

$$Emissions_{interval} = Time\ (hr)_{interval} \times\ Power(kW) \times EF(\frac{g}{kWh}) \times LLAF$$ **Equation 2-1**

Power is calculated for the propulsive (main), auxiliary, and auxiliary boiler engines for each interval and emission factor (EF) reflects the assigned emission factors for each engine, as described below. LLAF represents the low load adjustment factor, a unitless factor which reflects increasing propulsive emissions during low load operations. Time indicates the activity duration time between consecutive intervals.

Next, vessels were identified in order determine their vessel type, and thus their vessel group, power rating, and engine tier information which are required for the emissions calculations. See the 2017 NEI documentation for more details on this process. Following the identification, 108 different vessel types were matched to the C1C2 vessels. Vessel attribute data was not available for all these vessel types, so the vessel types were aggregated into 13 different vessel groups for which surrogate data were available as shown in Table 2-12. 11,302 vessels were directly identified by their ship and cargo number. The remaining group of miscellaneous ships represent 13 percent of the AIS vessels (excluding recreational vessels) for which a specific vessel type could not be assigned.

Table 2-12. Vessel groups in the cmv_c1c2 sector

Vessel Group	NEI Area Ship Count
Bulk Carrier	37
Commercial Fishing	1,147
Container Ship	7
Ferry Excursion	441
General Cargo	1,498
Government	1,338
Miscellaneous	1,475
Offshore support	1,149
Reefer	13
Ro Ro	26
Tanker	100
Tug	3,994
Work Boat	77
Total in Inventory:	11,302

As shown in Equation 2-1, power is an important component of the emissions computation. Vessel-specific installed propulsive power ratings and service speeds were pulled from Clarksons ship registry and adopted from the Global Fishing Watch (GFW) dataset when available. However, there is limited vessel specific attribute data for most of the C1C2 fleet. This necessitated the use of surrogate engine power and load factors, which were computed for each vessel group. In addition to the power required by propulsive engines, power needs for auxiliary engines were also computed for each vessel group. Emissions from main and auxiliary engines are inventoried with different SCCs as shown in Table 2-11.

The final components of the emissions computation equation are the emission factors and the low load adjustment factor. The emission factors used in this inventory take into consideration the EPA's marine vessel fuel regulations as well as exhaust standards that are based on the year that the vessel was manufactured to determine the appropriate regulatory tier. Emission factors in g/kWhr by tier for NO_x,

PM_{10}, $PM_{2.5}$, CO, CO_2, SO_2 and VOC were developed using Tables 3-7 through 3-10 in USEPA's (2008) Regulatory Impact Analysis on engines less than 30 liters per cylinder. To compile these emissions factors, population-weighted average emission factors were calculated per tier based on C1C2 population distributions grouped by engine displacement. Boiler emission factors were obtained from an earlier Swedish Environmental Protection Agency study (Swedish EPA, 2004). If the year of manufacture was unknown then it was assumed that the vessel was Tier 0, such that actual emissions may be less than those estimated in this inventory. Without more specific data, the magnitude of this emissions difference cannot be estimated.

Propulsive emissions from low-load operations were adjusted to account for elevated emission rates associated with activities outside the engines' optimal operating range. The emission factor adjustments were applied by load and pollutant, based on the data compiled for the Port Everglades 2015 Emission Inventory.[4] Hazardous air pollutants and ammonia were added to the inventory according to multiplicative factors applied either to VOC or $PM_{2.5}$.

The stack parameters used for cmv_c1c2 are a stack height of 1 ft, stack diameter of 1 ft, stack temperature of 70°F, and a stack velocity of 0.1 ft/s. These parameters force emissions into layer 1.

For more information on the emission computations for 2017, see the supporting documentation for the 2017 NEI C1C2 CMV emissions. The cmv_c1c2 emissions were aggregated to total hourly values in each grid cell and run through SMOKE as point sources. SMOKE requires an annual inventory file to go along with the hourly data, so those files were also generated for 2017.

2.4.2 Category 3 Commercial Marine Vessels (cmv_c3)

This sector contains large engine CMV emissions. Category 3 (C3) marine diesel engines are those at or above 30 liters per cylinder, typically these are the largest engines rated at 3,000 to 100,000 hp. C3 engines are typically used for propulsion on ocean-going vessels including container ships, oil tankers, bulk carriers, and cruise ships. Emissions control technologies for C3 CMV sources are limited due to the nature of the residual fuel used by these vessels.[5] The cmv_c3 sector contains sources that traverse state and federal waters; along with sources in waters not covered by the NEI in surrounding areas of Canada, Mexico, and international waters.

The cmv_c3 sources that operate outside of state waters but within the federal Emissions Control Area (ECA) are encoded with a FIPS state code of 85, with the "county code" digits representing broad regions such as the Atlantic, Gulf of Mexico, and Pacific. The ECA areas include parts of the Gulf of Mexico, and parts of the Atlantic and Pacific coasts. CMV C3 sources around Puerto Rico, Hawaii and Alaska, which are outside the ECA areas, are included in the inventory but are in separate files from the emissions

[4] USEPA. EPA and Port Everglades Partnership: Emission Inventories and Reduction Strategies. US Environmental Protection Agency, Office of Transportation and Air Quality, June 2018. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100UKV8.pdf.

[5] https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-marine-vessels.

around the continental United States (CONUS). The cmv_c3 sources in the inventory are categorized as operating either in-port or underway and are encoded using the SCCs listed in Table 2-13. and distinguish between diesel and residual fuel, in port areas versus underway, and main and auxiliary engines. In addition to C3 sources in state and federal waters, the cmv_c3 sector includes emissions in waters not covered by the NEI (FIPS = 98) and taken from the “ECA-IMO-based” C3 CMV inventory.[6] The ECA-IMO inventory is also used for allocating the FIPS-level emissions to geographic locations for regions within the domain not covered by the AIS selection boxes as described in the next section.

Table 2-13. SCCs for cmv_c3 sector

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2280002103	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Port emissions: Main Engine
2280002104	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Port emissions: Auxiliary Engine
2280002203	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Underway emissions: Main Engine
2280002204	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Underway emissions: Auxiliary Engine
2280003103	Mobile Sources	Marine Vessels, Commercial	Residual	C3 Port emissions: Main Engine
2280003104	Mobile Sources	Marine Vessels, Commercial	Residual	l C3 Port emissions: Auxiliary Engine
2280003203	Mobile Sources	Marine Vessels, Commercial	Residual	C3 Underway emissions: Main Engine
2280003204	Mobile Sources	Marine Vessels, Commercial	Residual	C3 Underway emissions: Auxiliary Engine

Prior to creation of the 2017 NEI, the EPA received Automated Identification System (AIS) data from United States Coast Guard (USCG) to quantify all ship activity which occurred between January 1 and December 31, 2017. The International Maritime Organization’s (IMO’s) International Convention for the Safety of Life at Sea (SOLAS) requires AIS to be fitted aboard all international voyaging ships with gross tonnage of 300 or more, and all passenger ships regardless of size.[7] In addition, the USCG has mandated that all commercial marine vessels continuously transmit AIS signals while transiting U.S. navigable

[6] https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf.
[7] International Maritime Organization (IMO) Resolution MSC.99(73) adopted December 12th. 2000 and entered into force July 1st, 2002; as amended by SOLAS Resolution CONF.5/32 adopted December 13th, 2002.

waters. As the vast majority of C3 vessels meet these requirements, any omitted from the inventory due to lack of AIS adoption are deemed to have a negligible impact on national C3 emissions estimates. The activity described by this inventory reflects ship operations within 200 nautical miles of the official U.S. baseline. This boundary is roughly equivalent to the border of the U.S Exclusive Economic Zone and the North American ECA, although some non-ECA activity is captured as well (Figure 2-4).

The 2017 NEI data were computed based on the AIS data from the USGS for the year of 2017. The AIS data were coupled with ship registry data that contained engine parameters, vessel power parameters, and other factors such as tonnage and year of manufacture which helped to separate the C3 vessels from the C1C2 vessels. Where specific ship parameters were not available, they were gap-filled. The types of vessels that remain in the C3 data set include bulk carrier, chemical tanker, liquified gas tanker, oil tanker, other tanker, container ship, cruise, ferry, general cargo, fishing, refrigerated vessel, roll-on/roll-off, tug, and yacht.

Prior to use, the AIS data were reviewed - data deemed to be erroneous were removed, and data found to be at intervals greater than 5 minutes were interpolated to ensure that each ship had data every five minutes. The five-minute average data provide a reasonably refined assessment of a vessel's movement. For example, using a five-minute average, a vessel traveling at 25 knots would be captured every two nautical miles that the vessel travels. For slower moving vessels, the distance between transmissions would be less.

The emissions were calculated for each C3 vessel in the dataset for each 5-minute time range and allocated to the location of the message following to the interval. Emissions were calculated according to Equation 2-2.

$$Emissions_{interval} = Time\ (hr)_{interval} \times\ Power(kW) \times EF(\frac{g}{kWh}) \times LLAF$$ **Equation 2-2**

Power is calculated for the propulsive (main), auxiliary, and auxiliary boiler engines for each interval and emission factor (EF) reflects the assigned emission factors for each engine, as described below. LLAF represents the low load adjustment factor, a unitless factor which reflects increasing propulsive emissions during low load operations. Time indicates the activity duration time between consecutive intervals.

Emissions were computed according to a computed power need (kW) multiplied by the time (hr) and by an engine-specific emission factor (g/kWh) and finally by a low load adjustment factor that reflects increasing propulsive emissions during low load operations.

The resulting emissions were available at 5-minute intervals. Code was developed to aggregate these emissions to modeling grid cells and up to hourly levels so that the emissions data could be input to SMOKE for emissions modeling with SMOKE. Within SMOKE, the data were speciated into the pollutants needed by the air quality model,[8] but since the data were already in the form of point sources at

[8] Ammonia (NH_3) was also added by SMOKE in the speciation step.

the center of each grid cell, and they were already hourly, no other processing was needed within SMOKE. SMOKE requires an annual inventory file to go along with the hourly data, so those files were also generated for 2017.

On January 1st, 2015, the ECA initiated a fuel sulfur standard which regulated large marine vessels to use fuel with 1,000 ppm sulfur or less. These standards are reflected in the cmv_c3 inventories.

There were some areas needed for modeling that the AIS request boxes did not cover (see Figure 2-4). These include a portion of the St. Lawrence Seaway transit to the Great Lakes, a small portion of the Pacific Ocean far offshore of Washington State, portions of the southern Pacific Ocean around off the coast of Mexico, and the southern portion of the Gulf of Mexico that is within the 36-km domain used for air quality modeling. In addition, a determination had to be made regarding whether to use the existing Canadian CMV inventory or the more detailed AIS-based inventory. The AIS-based inventory was used in the areas for which data were available, and the areas not covered were gap-filled with inventory data from the 2016beta platform (EPA and NEIC, 2019), which included data from Environment Canada and the 2011 ECA-IMO C3 inventory.

For the gap-filled areas not covered by AIS selections or the Environment Canada inventory, the 2016 nonpoint C3 inventory was converted to a point inventory to support plume rise calculations for C3 vessels. The nonpoint emissions were allocated to point sources using a multi-step allocation process because not all of the inventory components had a complete set of county-SCC combinations. In the first step, the county-SCC sources from the nonpoint file were matched to the county-SCC points in the 2011 ECA-IMO C3 inventory. The ECA-IMO inventory contains multiple point locations for each county-SCC. The nonpoint emissions were allocated to those points using the $PM_{2.5}$ emissions at each point as a weighting factor.

For cmv_c3 underway emissions without a matching FIPS in the ECA-IMO inventory were allocated using the 12 km 2014 offshore shipping activity spatial surrogate (surrogate code 806). Each county with underway emissions in the area inventory was allocated to the centroids of the cells associated with the respective county in the surrogate. The emissions were allocated using the weighting factors in the surrogate.

The resulting point emissions centered on each grid cell were converted to an annual point 2010 flat file format (FF10). A set of standard stack parameters were assigned to each release point in the cmv_c3 inventory. The assigned stack height was 65.62 ft, the stack diameter was 2.625 ft, the stack temperature was 539.6 °F, and the velocity was 82.02 ft/s. Emissions were computed for each grid cell needed for modeling.

2.4.3 Railway Locomotives (rail)

The rail sector includes all locomotives in the NEI nonpoint data category. This sector excludes railway maintenance locomotives and point source yard locomotives. Railway maintenance emissions are included in the nonroad sector. The point source yard locomotives are included in the ptnonipm sector. Typically in the NEI, yard locomotive emissions are split between the nonpoint and point categories, but for this study, all yard locomotive emissions are represented as point sources and included in the ptnonipm sector.

This study uses the 2017 rail inventory developed for the 2017 NEI by the Lake Michigan Air Directors Consortium (LADCO) and the State of Illinois with support from various other states. Class I railroad emissions are based on confidential link-level line-haul activity GIS data layer maintained by the Federal Railroad Administration (FRA). In addition, the Association of American Railroads (AAR) provided national emission tier fleet mix information. Class II and III railroad emissions are based on a comprehensive nationwide GIS database of locations where short line and regional railroads operate. Passenger rail (Amtrak) emissions follow a similar procedure as Class II and III, except using a database of Amtrak rail lines. Yard locomotive emissions are based on a combination of yard data provided by individual rail companies, and by using Google Earth and other tools to identify rail yard locations for rail companies which did not provide yard data. Information on specific yards were combined with fuel use data and emission factors to create an emissions inventory for rail yards. More detailed information on the development of the 2017 rail inventory for this study is available in the 2017 NEI TSD. The inventory SCCs are shown in Table 2-14.

Table 2-14. SCCs for the Rail Sector

SCC	Sector	Description: Mobile Sources prefix for all
2285002006	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations
2285002007	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations
2285002008	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)
2285002009	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines
2285002010	rail	Railroad Equipment; Diesel; Yard Locomotives (nonpoint)
28500201	rail	Railroad Equipment; Diesel; Yard Locomotives (point)

Class I Line-haul Methodology

In 2008, air quality planners in the eastern US formed the Eastern Technical Advisory Committee (ERTAC) for solving persistent emissions inventory issues. This work is the fourth inventory created by the ERTAC rail group. For the 2017 inventory, the Class I railroads granted ERTAC Rail permission to use the confidential link-level line-haul activity GIS data layer maintained by the Federal Railroad Administration (FRA) for 2016. In addition, the Association of American Railroads (AAR) provided national emission tier fleet mix information. This allowed ERTAC Rail to calculate weighted emission factors for each pollutant based on the percentage of the Class I line-haul locomotives in each USEPA Tier level category. These two datasets, along with 2017 Class I line-haul fuel use data reported to the Surface Transportation Board (Table 2-15), were used to create a link-level Class I emissions inventory, based on a methodology recommended by Sierra Research. Rail Fuel Consumption Index (RFCI) is a measure of fuel use per ton mile of freight. This link-level inventory is nationwide in extent, but it can be aggregated at either the state or county level.

Table 2-15. Class I Railroad Reported Locomotive Fuel Use Statistics for 2017

Class I Railroads	2017 R-1 Report Line-haul Gross Ton-Mile and Fuel Use Activity Data		RFCI (ton-miles/gal)	Adjusted RFCI (ton-miles/gal)
	Line-Haul*	Gross Ton-Miles		
BNSF	1,322,859,935	1,270,332,339,000	960	850
Canadian National	110,554,757	130,733,042,000	1,183	998
Canadian Pacific	64,373,234	68,787,636,000	1,069	1,260
CSX Transportation	392,481,373	428,879,185,000	1,093	1,075
Kansas City Southern	66,461,739	67,085,372,000	1,009	907
Norfolk Southern	430,036,855	415,580,691,000	966	920
Union Pacific	927,616,712	981,451,930,000	1,058	1,062
Totals:	**3,314,384,605**	**3,362,850,195,000**	**1,015**	**959**

* Includes work trains; Adjusted RFCI values calculated from FRA gross ton-mile data. RFCI total is ton-mile weighted mean.

Annual default emission factors for locomotives based on operating patterns ("duty cycles") and the estimated nationwide fleet mixes for both switcher and line-haul locomotives are available. However, Tier level fleet mixes vary significantly between the Class I and Class II/III railroads. As can be seen in Figure 2-5 and Figure 2-6, Class I railroad activity is highly regionalized in nature and is subject to variations in terrain across the country which can have a significant impact on fuel efficiency and overall fuel consumption.

Figure 2-5. 2017 US Railroad Traffic Density in Millions of Gross Tons per Route Mile (MGT)

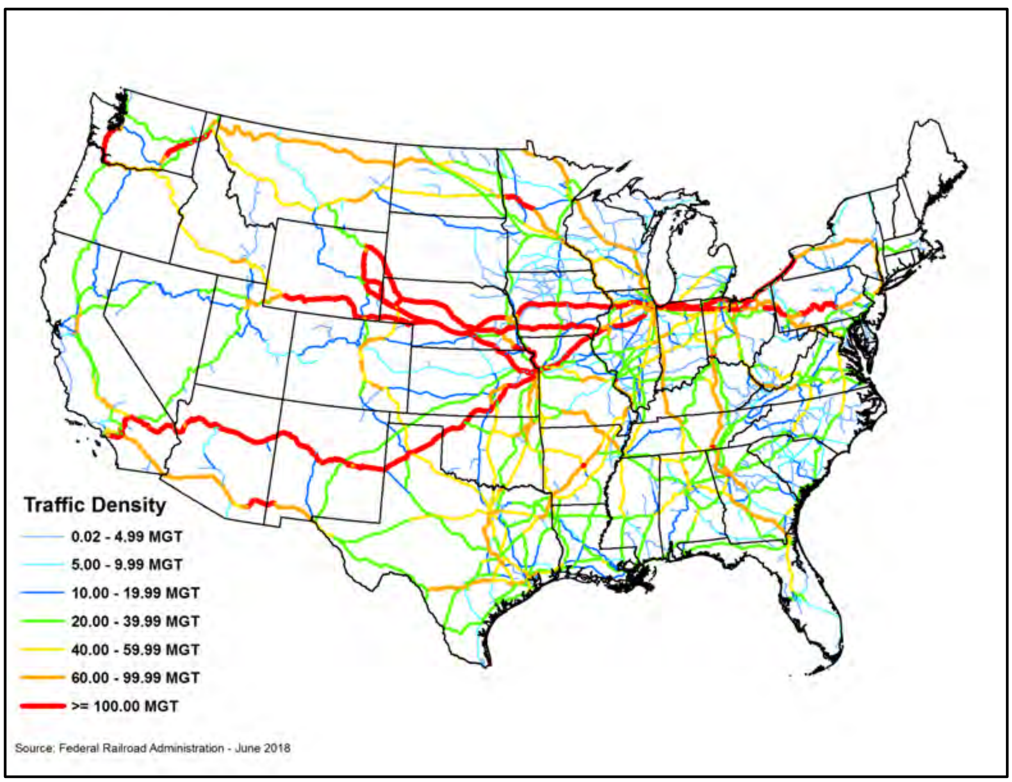
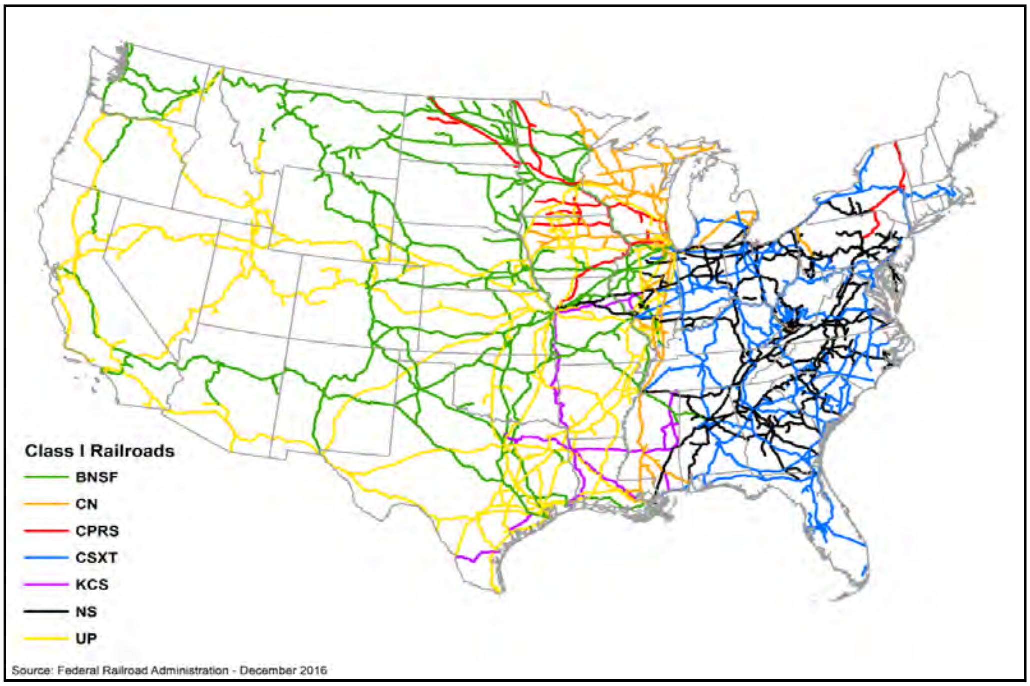


Figure 2-6. Class I Railroads in the United States



For the 2017 inventory, the AAR provided a national line-haul Tier fleet mix profile representing the entire Class I locomotive fleet. A locomotive's Tier level determines its allowable emission rates based on the year when it was built and/or re-manufactured. The national fleet mix data was then used to calculate weighted average in-use emissions factors for the line-haul locomotives operated by the Class I railroads as shown in Table 2-16.

Table 2-16. 2017 Line-haul Locomotive Emission Factors by Tier, AAR Fleet Mix (grams/gal)

Tier Level	AAR Fleet Mix Ratio	PM_{10}	HC	NO_x	CO
Uncontrolled (pre-1973)	0.035628	6.656	9.984	270.4	26.624
Tier 0 (1973-2001)	0.170656	6.656	9.984	178.88	26.624
Tier 0+ (Tier 0 rebuilds)	0.151779	4.16	6.24	149.76	26.624
Tier 1 (2002-2004)	0.018282	6.656	9.776	139.36	26.624
Tier 1+ (Tier 1 rebuilds)	0.243995	4.16	6.032	139.36	26.624
Tier 2 (2005-2011)	0.112198	3.744	5.408	102.96	26.624
Tier 2+ (Tier 2 rebuilds)	0.098125	1.664	2.704	102.96	26.624
Tier 3 (2012-2014)	0.123549	1.664	2.704	102.96	26.624
Tier 4 (2015 and later)	0.045789	0.312	0.832	20.8	26.624
2017 Weighted EF's	**1.000000**	**3.944**	**5.901**	**134.770**	**26.624**

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (grams/gal or lbs/gal) were calculated for the US Class I locomotive fleet based on the percentage of line-haul locomotives certified at each regulated Tier level (Equation 2-3).

$$EF_i = \sum_{T=1}^{9} EF_{iT} \times f_T \qquad \text{Equation 2-3}$$

where:

EF_i	=	Weighted Emission Factor for pollutant *i* for Class I locomotive fleet (g/gal).
EF_{iT}	=	Emission Factor for pollutant *i* for locomotives in Tier T (g/gal).
f_T	=	Percentage of the Class I locomotive fleet in Tier T expressed as a ratio.

While actual engine emissions will vary within Tier level categories, the approach described above likely provides reasonable emission estimates, as locomotive diesel engines are certified to meet the emission standards for each Tier. It should be noted that actual emission rates may increase over time due to engine wear and degradation of the emissions control systems. In addition, locomotives may be operated in a manner that differs significantly from the conditions used to derive line-haul duty-cycle estimates.

Emission factors for other pollutants are not Tier-specific because these pollutants are not directly regulated by USEPA's locomotive emission standards. $PM_{2.5}$ was assumed to be 97% of PM_{10}, the ratio of volatile organic carbon (VOC) to (hydrocarbon) HC was assumed to be 1.053, and the emission factors used for sulfur dioxide (SO_2) and ammonia (NH_3) were 0.0939 g/gal and 83.3 mg/gal, respectively. The 2017 SO_2 emission factor is based on the nationwide adoption of 15 ppm ultra-low sulfur diesel (ULSD) fuel by the rail industry.

The remaining steps to compute the Class 1 rail emissions involved calculating class I railroad-specific rail fuel consumption index values and calculating emissions per link. The final link-level emissions for each pollutant were then aggregated by state/county FIPS code and then converted into an FF10 file format for input to SMOKE. Detailed documentation methodology for this work is available in the Specification Sheet: Rail 2017 National Emissions Inventory on the 2017 NEI supporting data FTP site.

Rail yard Methodology

Rail yard emissions were computed based on fuel use and/or yard switcher locomotive counts for the class I rail companies for all of the rail yards on their systems. Three railroads provided complete rail yard datasets: BNSF, UP, and KCS. CSX provided switcher counts for its 14 largest rail yards. This reported activity data was matched to existing yard locations and data stored in USEPA's Emissions Inventory System (EIS) database. All existing EIS yards that had activity data assigned for prior years, but no reported activity data for 2017 were zeroed out. New yard data records were generated for reported locations that were not found in EIS. Special care was made to ensure that the new yards added to EIS did not duplicate existing data records. Data for non-Class I yards was carried forward from the 2014 NEI. Georgia provided updates on seven rail yards that were incorporated into 2017.

Since the railroads only supplied switcher counts, average fuel use per switcher values was calculated for each railroad. This was done by dividing each company's 2017 R-1 yard fuel use total by the number of switchers reported for each railroad. These values were then used to allocate fuel use to each yard based on the number of switchers reported for that location. Table 2-17 summarizes the 2017 yard fuel use and switcher data for each Class I railroad. The emission factors used for rail yard switcher engines are shown in Table 2-18.

Table 2-17. Surface Transportation Board R-1 Fuel Use Data – 2017

Railroad	2017 Yard Fuel Use (gal)	Identified Switchers	ERTAC per Switcher Fuel Use (gal)
BNSF	43,946,592	437	100,564
CSXT	38,404,906	416	92,305
CN	6,893,180	103	66,924
KCS	3,143,526	176	17,860
NS	30,730,245	457	67,243
CPRS	1,267,536	70	18,108
UP	87,707,002	1286	68,201
All Class I's	**212,092,987**	**2,945**	**61,601**

Table 2-18. 2017 Yard Switcher Emission Factors by Tier, AAR Fleet Mix (grams/gal)[4]

Tier Level	AAR Fleet Mix Ratio	PM_{10}	HC	NO_x	CO
Uncontrolled (pre-1973)	0.2601	6.688	15.352	264.48	27.816
Tier 0 (1973-2001)	0.2361	6.688	15.352	191.52	27.816
Tier 0+ (Tier 0 rebuilds)	0.2599	3.496	8.664	161.12	27.816
Tier 1 (2002-2004)	0.0000	6.536	15.352	150.48	27.816
Tier 1+ (Tier 1 rebuilds)	0.0476	3.496	8.664	150.48	27.816
Tier 2 (2005-2011)	0.0233	2.888	7.752	110.96	27.816
Tier 2+ (Tier 2 rebuilds)	0.0464	1.672	3.952	110.96	27.816
Tier 3 (2012-2014)	0.1018	1.216	3.952	68.4	27.816
Tier 4 (2015 and later)	0.0247	0.228	1.216	15.2	27.816
2017Weighted EF's	**0.9999**	**4.668**	**11.078**	**178.1195**	**27.813**

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. AAR fleet mix ratios did not add up to 1.0000, which caused a small error for the CO weighted emission factor as shown above.

In addition to the Class I rail yards, Emission estimates were calculated for four large Class III railroad hump yards which are among the largest classification facilities in the United States. These four yards are located in Chicago (Belt Railway of Chicago-Clearing and Indiana Harbor Belt-Blue Island) and Metro-East St. Louis (Alton & Southern-Gateway and Terminal Railroad Association of St. Louis-Madison). Figure 2-7 shows the spatial distribution of active yards in the 2016 version 1 (2016v1) and 2017 NEI inventories.

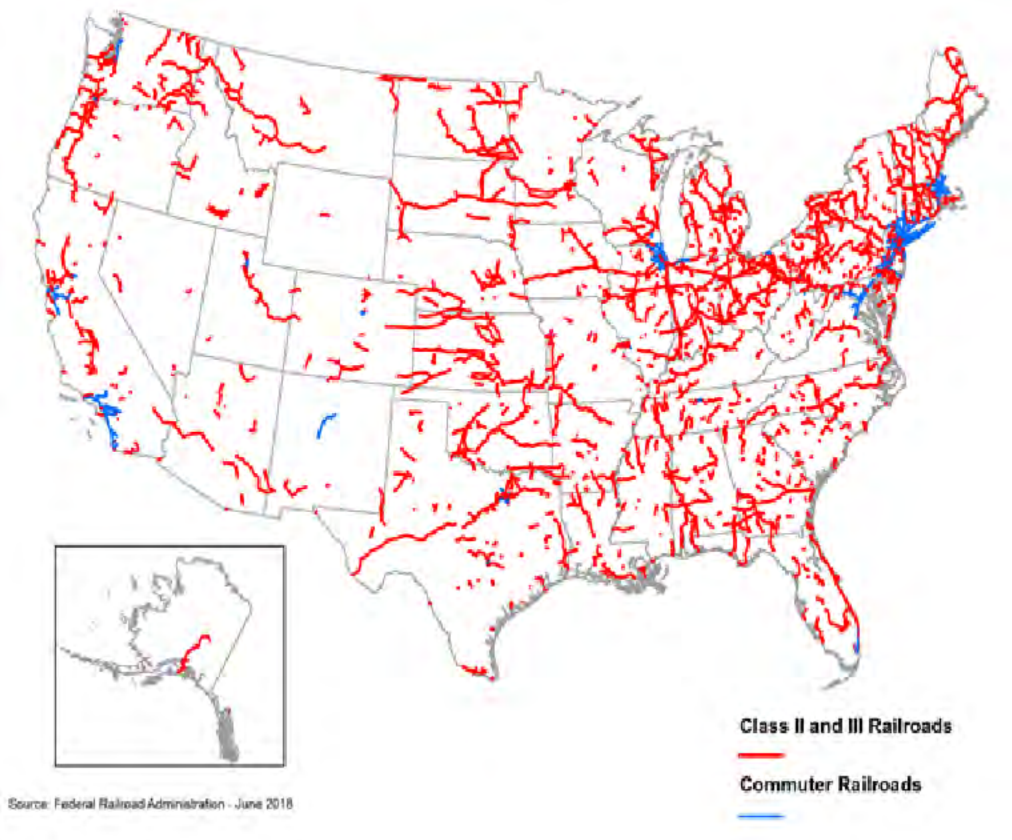
Figure 2-7. 2016-2017 Active Rail Yard Locations in the United States

Class II and III Methodology

There are approximately 560 Class II and III Railroads operating in the United States, most of which are members of the American Short Line and Regional Railroad Association (ASLRRA). While there is a lot of information about individual Class II and III railroads available online, a significant amount of effort would be required to convert this data into a usable format for the creation of emission inventories. In addition, the Class II and III rail sector has been in a constant state of flux ever since the railroad industry was deregulated under the Staggers Act in 1980. Some states have conducted independent surveys of their Class II and III railroads and produced emission estimates, but no national level emissions inventory existed for this sector of the railroad industry prior to ERTAC Rail's work for the 2008 NEI.

Class II and III railroad activities account for nearly 4 percent of the total locomotive fuel use in the combined ERTAC Rail emission inventories and for approximately 35 percent of the industry's national freight rail track mileage. These railroads are widely dispersed across the country and often utilize older, higher emitting locomotives than their Class I counterparts. Class II and III railroads provide transportation services to a wide range of industries. Individual railroads in this sector range from small switching operations serving a single industrial plant to large regional railroads that operate hundreds of miles of track. Figure 2-8 shows the distribution of Class II and III railroads and commuter railroads across the country. This inventory will be useful for regional and local modeling, helps identify where Class II and III railroads may need to be better characterized, and provides a strong foundation for the future development of a more accurate nationwide short line and regional railroad emissions inventory. A picture of the locations of class II and III railroads is shown in Figure 2-8. Detailed documentation methodology for this work is available in the Specification Sheet: Rail 2017 National Emissions Inventory on the 2017 Supplemental data FTP site.

Figure 2-8. Class II and III Railroads in the United States[5]



Commuter Rail Methodology

Commuter rail emissions were calculated in the same way as the Class II and III railroads. The primary difference is that the fuel use estimates were based on data collected by the Federal Transit Administration (FTA) for the National Transit Database. For the 2017 NEI, 2016 fuel use was estimated for each of the commuter railroads shown in Table 2-19 by multiplying the fuel and lube cost total by 0.95, then dividing the result by Metra's average diesel fuel cost of $1.93/gallon. These fuel use estimates were replaced with reported fuel use statistics for MARC (Maryland), MBTA (Massachusetts), Metra (Illinois), and NJT (New Jersey). The commuter railroads were separated from the Class II and III railroads so that the appropriate SCC codes could be entered into the emissions calculation sheet.

Table 2-19. Expenditures and fuel use for commuter rail

FRA Code	System	Cities Served	Propulsion Type	DOT Fuel & Lube Costs	Reported/Estimated Fuel Use
ACEX	Altamont Corridor Express	San Jose / Stockton	Diesel	$889,828	437,998.24
CMRX	Capital MetroRail	Austin	Diesel	No data	n/a
DART	A-Train	Denton	Diesel	$0	0.00

FRA Code	System	Cities Served	Propulsion Type	DOT Fuel & Lube Costs	Reported/Estimated Fuel Use
DRTD	Denver RTD: A&B Lines	Denver	Electric	$0	0.00
JPBX	Caltrain	San Francisco / San Jose	Diesel	$7,002,612	3,446,881.55
LI	MTA Long Island Rail Road	New York	Electric and Diesel	$13,072,158	6,434,481.92
MARC	MARC Train	Baltimore / Washington, D.C.	Diesel and Electric	$4,648,060	***4,235,297.57***
MBTA	MBTA Commuter Rail	Boston / Worcester / Providence	Diesel	$37,653,001	***12,142,826.00***
MNCW	MTA Metro-North Railroad	New York / Yonkers / Stamford	Electric and Diesel	$13,714,839	6,750,827.49
NICD	NICTD South Shore Line	Chicago / South Bend	Electric	$181,264	0.00
NIRC	Metra	Chicago	Diesel and Electric	$52,460,705	***25,757,673.57***
NJT	New Jersey Transit	New York / Newark / Trenton / Philadelphia	Electric and Diesel	$38,400,031	***16,991,164.00***
NMRX	New Mexico Rail Runner	Albuquerque / Santa Fe	Diesel	$1,597,302	786,236.74
CFCR	SunRail	Orlando	Diesel	$856,202	421,446.58
MNRX	Northstar Line	Minneapolis	Diesel	$708,855	348,918.26
Not Coded	SMART	San Rafael-Santa Rosa (Opened 2017)	Diesel	n/a	0.00
NRTX	Music City Star	Nashville	Diesel	$456,099	224,504.69
SCAX	Metrolink	Los Angeles / San Bernardino	Diesel	$19,245,255	9,473,052.98
SDNR	NCTD Coaster	San Diego / Oceanside	Diesel	$1,489,990	733,414.77
SDRX	Sounder Commuter Rail	Seattle / Tacoma	Diesel	$1,868,019	919,491.22
SEPA	SEPTA Regional Rail	Philadelphia	Electric	$483,965	0.00
SLE	Shore Line East	New Haven	Diesel	No data	n/a
TCCX	Tri-Rail	Miami / Fort Lauderdale / West Palm Beach	Diesel	$5,166,685	2,543,186.92
TREX	Trinity Railway Express	Dallas / Fort Worth	Diesel	No data	n/a
UTF	UTA FrontRunner	Salt Lake City / Provo	Diesel	$4,044,265	1,990,700.39
VREX	Virginia Railway Express	Washington, D.C.	Diesel	$3,125,912	1,538,661.35
WSTX	Westside Express Service	Beaverton	Diesel	No data	n/a

*Reported fuel use values were used for MARC, MBTA, Metra, and New Jersey Transit.

Intercity Passenger Methodology (Amtrak)

2016 and 2017 marked the first times that a nationwide intercity passenger rail emissions inventory was created for Amtrak. The calculation methodology mimics that used for the Class II and III and commuter railroads with a few modifications. Since link-level activity data for Amtrak was unavailable, the default assumption was made to evenly distribute Amtrak's 2016 reported fuel use across all of it diesel-powered route-miles shown in Figure 2-9. Participating states were instructed that they could alter the fuel use distribution within their jurisdictions by analyzing Amtrak's 2016 national timetable and calculating passenger train-miles for each affected route. Illinois and Connecticut chose to do this and were able to derive activity-based fuel use numbers for their states based on Amtrak's 2016 reported average fuel use of 2.2 gallons per passenger train-mile. In addition, Connecticut provided supplemental data for selected counties in Massachusetts, New Hampshire, and Vermont. Amtrak also submitted company-specific fleet mix information and company-specific weighted emission factors were derived. Amtrak's emission rates were 25% lower than the default Class II and III and commuter railroad emission rate. Detailed documentation methodology for this work is available in the Specification Sheet: Rail 2017 National Emissions Inventory on the 2017 NEI supporting data FTP site.

Figure 2-9. Amtrak Routes with Diesel-powered Passenger Trains

Other Data Sources

The California Air Resources Board (CARB) provided rail inventories for inclusion in the 2017 NEI. CARB's rail inventories were used in California, in place of the national dataset described above. For rail yards, the national point source rail yard dataset was used to allocate CARB-submitted rail yard emissions to point sources where possible. That is, for each California county with at least one rail yard in the national dataset, the emissions in the national rail yard dataset were adjusted so that county total rail yard emissions matched the CARB dataset. In other words, county total rail yard emissions from CARB are used, but the locations of rail yards are based on the national methodology. There are three counties with CARB-submitted rail yard emissions, but no rail yard locations in the national dataset; for those counties, the rail yard emissions were included in the rail sector using SCC 2285002010.

HAPs were not provided with the rail inventory but were augmented for the NEI. For VOC speciation, the EPA preferred augmenting the inventory with HAPs and using those HAPs for integration, rather than running the sector as a no-integrate sector.

2.4.4 Nonroad Mobile Equipment (nonroad)

The mobile nonroad equipment sector includes all mobile source emissions that do not operate on roads, excluding commercial marine vehicles, railways, and aircraft. Types of nonroad equipment include recreational vehicles, pleasure craft, and construction, agricultural, mining, and lawn and garden equipment. Nonroad equipment emissions were computed by running MOVES2014b[9] which incorporates the NONROAD model. MOVES2014b incorporated updated nonroad engine population growth rates, nonroad Tier 4 engine emission rates, and sulfur levels of nonroad diesel fuels. MOVES provides a complete set of HAPs and incorporates updated nonroad emission factors for HAPs. MOVES was used for all states other than California, which developed their own emissions using their own tools. VOC and PM speciation profile assignments are determined by MOVES and applied by SMOKE. The fuels data in MOVES3 for nonroad vehicles is slightly updated from the MOVES2014b fuels for nonroad vehicles.

MOVES2014b creates a monthly emissions inventory for criteria air pollutants (CAPs) and a full set of HAPs, plus additional pollutants such as NONHAPTOG and ETHANOL, which are not part of the NEI but are used for speciation. MOVES2014b provides estimates of NONHAPTOG along with the speciation profile code for the NONHAPTOG emission source. This was accomplished by using NHTOG#### as the pollutant code in the Flat File 2010 (FF10) inventory file that can be read into SMOKE, where #### is a speciation profile code. For California, NHTOG####-VOC and HAP-VOC ratios from MOVES-based emissions were applied to VOC emissions from California so that VOC emissions in California can be speciated consistently with other states.

MOVES2014b, unlike MOVES2014a, also provides estimates of PM2.5 by speciation profile code for the PM2.5 emission source, using PM25_#### as the pollutant code in the FF10 inventory file, where #### is a speciation profile code. To facilitate calculation of PMC within SMOKE, and to help create emissions summaries, an additional pollutant representing total PM2.5 called PM25TOTAL was added to the inventory. As with VOC, PM25_####-PM25TOTAL ratios were calculated and applied to PM2.5 emissions in California so that PM2.5 emissions in California can be speciated consistently with other states.

MOVES3 outputs emissions data in county-specific databases, and a post-processing script converts the data into FF10 format. Additional post-processing steps were performed as follows:

- County-specific FF10s were combined into a single FF10 file.

[9] https://www.epa.gov/moves.

- Emissions were aggregated from the more detailed SCCs modeled in MOVES to the SCCs modeled in SMOKE. A list of the aggregated SMOKE SCCs is in Appendix A of the 2016v1 platform nonroad specification sheet (NEIC, 2019).
- To reduce the size of the inventory, HAPs that are not needed for air quality modeling, such as dioxins and furans, were removed from the inventory.
- To reduce the size of the inventory further, all emissions for sources (identified by county/SCC) for which total CAP emissions are less than $1*10^{-10}$ were removed from the inventory. The MOVES model attributes a very tiny amount of emissions to sources that are actually zero, for example, snowmobile emissions in Florida. Removing these sources from the inventory reduces the total size of the inventory by about 7%.
- Gas and particulate components of HAPs that come out of MOVES separately, such as naphthalene, were combined.
- VOC was renamed VOC_INV so that SMOKE does not speciate both VOC and NONHAPTOG, which would result in a double count.
- PM25TOTAL, referenced above, was also created at this stage of the process.
- Emissions for airport ground support vehicles (SCCs ending in -8005), and oil field equipment (SCCs ending in -10010), were removed from the inventory at this stage, to prevent a double count with the airports and np_oilgas sectors, respectively.
- California emissions from MOVES were deleted and replaced with the CARB-supplied emissions.

National Updates: Agricultural and Construction Equipment Allocation

The methodology for developing Agricultural equipment allocation data for the 2016v1 platform was developed by the North Carolina Department of Environmental Quality (NCDEQ). EPA updated the Construction equipment allocation data used in MOVES for the 2016v1 platform and the same updated data were used in the 2017 NEI.

NCDEQ compiled regional and state-level Agricultural sector fuel expenditure data for 2016 from the US Department of Agriculture, National Agricultural Statistics Service (NASS), August 2018 publication, "Farm Production Expenditures 2017 Summary."[10] This resource provides expenditures for each of 5 major regions that cover the Continental U.S., as well as state-level data for 15 major farm producing states. Because of the limited coverage of the NASS source relative to that in MOVES, it was necessary to identify a means for estimating the 2016 Agricultural sector allocation data for the following States and Territories from a different source: Alaska, Hawaii, Puerto Rico, and U.S. Virgin Islands. The approach for these areas is described below.

For the Continental U.S., NCDEQ first allocated the remainder of the regional fuel expenditures to states in each region for which state-level data are not reported. For this allocation, NCDEQ relied on 2012 fuel expenditure data from NASS' 2012 Census of Agriculture (note that 2017 data were not yet available at

[10] Accessed from http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1066, November 2018.

the time of this effort).[11] The next step to developing county-level allocation data for agricultural equipment was to multiply the state-level fuel expenditure estimates by county-level allocation ratios. These allocation ratios were computed from county-level fuel expenditure data from the NASS' 2012 Census of Agriculture. There were 17 counties for which fuel expenditure data were withheld in the Census of Agriculture. For these counties, NCDEQ allocated the fuel expenditures that were not accounted for in the applicable state via a surrogate indicator of fuel expenditures. For most states, the 2012 Census of Agriculture's total machinery asset value was the surrogate indicator used to perform the allocation. This indicator was found to have the strongest correlation to agricultural sector fuel expenditures based on analysis of 2012 state-level Census of Agriculture values for variables analyzed (correlation coefficient of 0.87).[12] Because the analyzed surrogate variables were not available for the two counties in New York without fuel expenditure data, farm sales data from the 2012 Census of Agriculture were used in the allocation procedure for these counties.

For Alaska and Hawaii, NCDEQ estimated 2016 state-level fuel production expenditures by first applying the national change in fuel expenditures between 2012 and 2016 from NASS' "Farm Production Expenditures" summary publications to 2012 state expenditure data from the 2012 Census of Agriculture. Next, NCDEQ applied an adjustment factor to account for the relationship between national 2012 fuel expenditures as reported by the Census of Agriculture and those reported in the Farm Production Expenditures Summary. Hawaii's state-level fuel expenditures were allocated to counties using the same approach as the states in the Continental U.S. (i.e., county-level fuel expenditure data from the NASS' 2012 Census of Agriculture). Alaska's fuel expenditures total was allocated to counties using a different approach because the 2012 Census of Agriculture reports fuel expenditures data for a different list of counties than the one included in MOVES. To ensure consistency with MOVES, NCDEQ allocated Alaska's fuel expenditures based on the current allocation data in MOVES, which reflect 2002 harvested acreage data from the Census of Agriculture.

Because NCDEQ did not identify any source of fuel expenditures data for Puerto Rico or the U.S. Virgin Islands, the county allocation percentages that are represented by the 2002 MOVES allocation data were used for these territories.[13]

For the Construction sector, by default MOVES2014b used estimates of 2003 total dollar value of construction by county to allocate national Construction equipment populations to the state and local levels.[14] The 2016 National Emissions Inventory Collaborative (NEIC) Nonroad Work Group sought to update the surrogate data used to geographically allocate Construction equipment with a more recent data source thought to be more reflective of emissions-generating Construction equipment activity at the county level: acres disturbed by residential, non-residential, and road construction activity.

The nonpoint sector of the National Emissions Inventory (NEI) includes estimates of Construction Dust ($PM_{2.5}$), for which acreage disturbed by residential, non-residential, and road construction activity is a function.[15] The 2017 NEI Technical Support Document (EPA, 2021) includes a description of the methods used to estimate acreage disturbed at the county level by residential, non-residential, and road construction activity, for the 50 states.

[11] Accessed from https://www.nass.usda.gov/Publications/AgCensus/2012/, November 2018.
[12] Other variables analyzed were inventory of tractors and inventory of trucks.
[13] For reference, these allocations were 0.0639 percent for Puerto Rico and 0.0002 percent for the U.S. Virgin Islands.
[14] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1004LDX.pdf.
[15] https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data.

Acreage disturbed by residential, non-residential, and road construction were summed together to arrive at a single value of acreage disturbed by Construction activities at the county level. County-level acreage disturbed were then summed together to arrive at acreage disturbed at the state level. State totals were then summed to arrive at a national total of acreage disturbed by Construction activities.

Puerto Rico and the U.S. Virgin Islands are not included in the Construction equipment geographic allocation update, so their relative share of the national population of Construction equipment remains the same as MOVES2014b defaults.

For both the Agricultural and Construction equipment sectors, the *surrogatequant* and *surrogateyearID* fields in the model's *nrstatesurrogate* table, which allocates equipment from the state- to the county-level, were populated with the county-level surrogates described above (fuel expenditures in 2016 for Agricultural equipment; acreage disturbed by construction activity in 2014 for Construction equipment). In addition, the *nrbaseyearequippopulation* table, which apportions the model's national equipment populations to the state level, was adjusted so that each state's share of the MOVES base-year national populations of Agricultural and Construction equipment is proportional to each state's share of national acreage disturbed by construction activity (Construction equipment) and agricultural fuel expenditures (Agricultural equipment). Additionally, the model's *nrsurrogate* table, which defines the surrogate data used in the *nrstatesurrogate* table, was updated to reflect the changes to the Agricultural and Construction equipment sectors made as part of the 2016v1 platform development process.

Updated *nrsurrogate*, *nrstatesurrogate*, and *nrbaseyearequippopulation* tables, along with instructions for utilizing these tables in MOVES runs, are available for download from EPA's ftp site: https://gaftp.epa.gov/air/emismod/2016/v1/reports/nonroad/).

State-Supplied Nonroad Data

As shown Table 2-20. several state and local agencies provided nonroad inputs for use in the 2017 NEI. Additionally, per the table footnotes, EPA reviewed data submitted by state and local agencies for the 2014 and 2017 National Emissions Inventories and utilized that information where appropriate.

Table 2-20. Submitted nonroad input tables by agency

statеid	State or County(ies) in the Agency	**nrbaseyearequippopulation** (source populations)	**nrdayallocation** (allocation to day type)	**Nrfuelsupply** (allocation of fuels)	**nrgrowthindex** (population growth)	**nrhourallocation** (allocation to diurnal pattern)	**nrmonthallocation** (seasonal allocation)	**nrsourceusetype** (yearly activity)	**nrstatesurrogate** (allocations to counties)	**countyyear** (Stage II information)	**nrequipmenttype** (surrogate selection)	**nrsurrogate** (surrogate identification)
4	ARIZONA - Maricopa Co.	A		X				A	A	A	A	A
9	CONNECTICU	A										
13	GEORGIA			A					A			
16	IDAHO		C									
17	ILLINOIS						D					
18	INDIANA		C				D					
19	IOWA		C				D					
26	MICHIGAN		C				D					
27	MINNESOTA	A	C				D					
29	MISSOURI						D					
36	NEW YORK	A	A	X	A	A	A	A	A			
39	OHIO		C				D					
48	TEXAS	A	A X			A				A	A	
49	UTAH	B	A		A	A		A	E			
53	WASHINGTO								A		A	A
55	WISCONSIN						D					

[A] Submitted data.

[B] Submitted data with modification: deleted records that were not snowmobile source types 1002-1010.

[C] 2014NEIv2 data used for 2017 NEI.

[D] Spreadsheet "ladco_nei2017_nrmonthallocation.xlsx" (see discussion below)

[E] Submitted data with modification: deleted records that were not the snowmobile surrogate ID 14.

[X] Submitted data not used in 2017 NEI. The GA NRFuelSupply table is only used to divide counties into groups.

Emissions Inside California

California nonroad emissions were provided by CARB for 2017.

All California nonroad inventories are annual, with monthly temporalization applied in SMOKE. Emissions for oil field equipment (SCCs ending in -10010) were removed from the California inventory in order to prevent a double count with the np_oilgas sector. VOC and $PM_{2.5}$ emissions were allocated to speciation profiles, and VOC HAPs were created, using MOVES data in California. For example, ratios of VOC ($PM_{2.5}$) by speciation profile to total VOC ($PM_{2.5}$), and ratios of VOC HAPs to total VOC, were calculated by county and SCC from the MOVES run in California, and then applied CARB-provided VOC ($PM_{2.5}$) in the inventory so that California nonroad emissions could be speciated consistently with the rest of the country.

Nonroad Updates from State Comments

The 2016 Nonroad Collaborative workgroup received a small number of comments on the 2016beta inventory (EPA and NEIC, 2019), all of which were addressed and implemented in the 2017 NEI nonroad inventory:

- **Georgia Department of Natural Resources:** utilize updated geographic allocation factors (*nrstatesurrogate* table) for the Commercial, Lawn & Garden (commercial, public, and residential), Logging, Manufacturing, Golf Carts, Recreational, Railroad Maintenance Equipment and A/C/Refrigeration sectors, using data from the U.S. Census Bureau and U.S. Forest Service.
- **Lake Michigan Air Directors Consortium (LADCO):** update seasonal allocation of agricultural equipment activity (*nrmonthallocation* table) for Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.
- **Texas Commission on Environmental Quality:** replace MOVES nonroad emissions for Texas with emissions calculated with TCEQ's TexN2 model.
- **Alaska Department of Environmental Conservation:** remove emissions as calculated by MOVES for several equipment sector-county/census areas combinations in Alaska, due to an absence of nonroad activity (see Table 2-21).

Table 2-21. Alaska counties/census areas for which nonroad equipment sector-specific emissions were removed

Nonroad Equipment Sector	Counties/Census Areas (FIPS) for which equipment sector emissions are removed in 2016
Agricultural	Aleutians East (02013), Aleutians West (02016), Bethel Census Area (02050), Bristol Bay Borough (02060), Dillingham Census Area (02070), Haines Borough (02100), Hoonah-Angoon Census Area (02105), Ketchikan Gateway (02130), Kodiak Island Borough (02150), Lake and Peninsula (02164), Nome (02180), North Slope Borough (02185), Northwest Arctic (02188), Petersburg Borough (02195), Pr of Wales-Hyder Census Area (02198), Sitka Borough (02220), Skagway Borough (02230), Valdez-Cordova Census Area (02261), Wade Hampton Census Area (02270), Wrangell City + Borough (02275), Yakutat City + Borough (02282), Yukon-Koyukuk Census Area (02290)
Logging	Aleutians East (02013), Aleutians West (02016), Nome (02180), North Slope Borough (02185), Northwest Arctic (02188), Wade Hampton Census Area (02270)
Railway Maintenance	Aleutians East (02013), Aleutians West (02016), Bethel Census Area (02050), Bristol Bay Borough (02060), Dillingham Census Area (02070), Haines Borough (02100), Hoonah-Angoon Census Area (02105), Juneau City + Borough (02110), Ketchikan Gateway (02130), Kodiak

Nonroad Equipment Sector	Counties/Census Areas (FIPS) for which equipment sector emissions are removed in 2016
	Island Borough (02150), Lake and Peninsula (02164), Nome (02180),), North Slope Borough (02185), Northwest Arctic (02188), Petersburg Borough (02195), Pr of Wales-Hyder Census Area (02198), Sitka Borough (02220), Southeast Fairbanks (02240), Wade Hampton Census Area (02270), Wrangell City + Borough (02275), Yakutat City + Borough (02282), Yukon-Koyukuk Census Area (02290)

2.5 Fires (ptfire, ptagfire)

Multiple types of fires are represented in the modeling platform. These include wild and prescribed fires that are grouped into the ptfire sector, and agricultural fires that comprise the ptagfire sector. All ptfire and ptagfire fires are in the United States. Fires outside of the United States are described in the ptfire_othna sector later in this document.

2.5.1 Wild and Prescribed Fires (ptfire)

Wildfire and prescribed burning emissions are contained in the ptfire sector. The ptfire sector has emissions provided at geographic coordinates (point locations) and has daily emissions values. The ptfire sector excludes agricultural burning and other open burning sources that are included in the ptagfire sector. Emissions are day-specific and include satellite-derived latitude/longitude of the fire's origin and other parameters associated with the emissions such as acres burned and fuel load, which allow estimation of plume rise.

The SCCs used for the ptfire sources are shown in Table 2-22. The ptfire inventory includes separate SCCs for the flaming and smoldering combustion phases for wildfire and prescribed burns. Note that prescribed grassland fires or Flint Hills, Kansas have their own SCC (2811021000) in the inventory. These wild grassland fires were assigned the standard wildfire SCCs shown in Table 2-22.

Table 2-22. SCCs included in the ptfire sector for the 2017 inventory

SCC	Description
2810001001	Forest Wildfires; Smoldering; Residual smoldering only (includes grassland wildfires)
2810001002	Forest Wildfires; Flaming (includes grassland wildfires)
2811015001	Prescribed Forest Burning; Smoldering; Residual smoldering only
2811015002	Prescribed Forest Burning; Flaming
2811020002	Prescribed Rangeland Burning
2811021000	Prescribed Rangeland Burning - Tallgrass Prairie

Fire Information Data

Inputs to SMARTFIRE for 2017 include (see Section 7 of the 2017 NEI TSD for more details):

- The National Oceanic and Atmospheric Administration's (NOAA's) Hazard Mapping System (HMS) fire location information

- GeoMAC (Geospatial Multi-Agency Coordination), an online wildfire mapping application designed for fire managers to access maps of current fire locations and perimeters in the United States
- The Incident Status Summary, also known as the “ICS-209”, used for reporting specific information on fire incidents of significance
- Incident reports including dates of fire activity, acres burned, and fire locations from the National Association of State Foresters (NASF)
- Hazardous fuel treatment reduction polygons for prescribed burns from the Forest Service Activity Tracking System (FACTS)
- Fire activity on federal lands from the United States Fish and Wildlife Service (USFWS)
- Wildfire and prescribed date, location, and locations from S/L/T activity submitters

The Hazard Mapping System (HMS) was developed in 2001 by the National Oceanic and Atmospheric Administration’s (NOAA) National Environmental Satellite and Data Information Service (NESDIS) as a tool to identify fires over North America in an operational environment. The system utilizes geostationary and polar orbiting environmental satellites. Automated fire detection algorithms are employed for each of the sensors. When possible, HMS data analysts apply quality control procedures for the automated fire detections by eliminating those that are deemed to be false and adding hotspots that the algorithms have not detected via a thorough examination of the satellite imagery.

The HMS product used for the 2017 inventory consisted of daily comma-delimited files containing fire detect information including latitude-longitude, satellite used, time detected, and other information. These detects were processed through Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and BlueSky Framework.

GeoMAC (Geospatial Multi-Agency Coordination) is an online wildfire mapping application designed for fire managers to access maps of current U.S. fire locations and perimeters. The wildfire perimeter data is based upon input from incident intelligence sources from multiple agencies, GPS data, and infrared (IR) imagery from fixed wing and satellite platforms.

The Incident Status Summary, also known as the “ICS-209” is used for reporting specific information on significant fire incidents. The ICS-209 report is a critical interagency incident reporting tool giving daily ‘snapshots’ of the wildland fire management situation and individual incident information which include fire behavior, size, location, cost, and other information. Data from two tables in the ICS-209 database were merged and used for the 2016v1 ptfire inventory: the SIT209_HISTORY_INCIDENT_209_REPORTS table contained daily 209 data records for large fires, and the SIT209_HISTORY_INCIDENTS table contained summary data for additional smaller fires.

The National Association of State Foresters (NASF) is a non-profit organization composed of the directors of forestry agencies in the states, U.S. territories, and District of Columbia to manage and protect state and private forests, which encompass nearly two-thirds of the nation's forests. The NASF compiles fire incident reports from agencies in the organization and makes them publicly available. The NASF fire information includes dates of fire activity, acres burned, and fire location information.

Monitoring Trends in Burn Severity (MTBS) is an interagency program whose goal is to consistently map the burn severity and extent of large fires across the U.S. from 1984 to present. The MTBS data includes all fires 1,000 acres or greater in the western United States and 500 acres or greater in the eastern United States. The extent of coverage includes the continental U.S., Alaska, Hawaii, and Puerto Rico. Fire occurrence and satellite data from various sources are compiled to create numerous MTBS fire products. The MTBS Burned Areas Boundaries Dataset shapefiles include year 2017 fires and that are classified as either wildfires, prescribed burns or unknown fire types. The unknown fire type shapes were omitted in the 2016v1 inventory development due to temporal and spatial problems found when trying to use these data.

The US Forest Service (USFS) compiles a variety of fire information every year. Year 2016 data from the USFS Natural Resource Manager (NRM) Forest Activity Tracking System (FACTS) were acquired and used for 2016v1 emissions inventory development. This database includes information about activities related to fire/fuels, silviculture, and invasive species. The FACTS database consists of shapefiles for prescribed burns that provide acres burned and start and ending time information.

The US Fish and Wildland Service (USFWS) also compiles wildfire and prescribed burn activity on their federal lands every year. Year 2017 data were acquired from USFWS through direct communication with USFWS staff and were used for 2017 emissions inventory development.   The USFWS fire information provided fire type, acres burned, latitude-longitude, and start and ending times.

Fire Emissions Estimation Methodology

The national and S/L/T data mentioned earlier were used to estimate daily wildfire and prescribed burn emissions from flaming combustion and smoldering combustion phases for the 2017 inventory. Flaming combustion is more complete combustion than smoldering and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion occurs without a flame, is a less complete burn, and produces some pollutants, such as PM2.5, VOCs, and CO, at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface-to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions), but for the purposes of the inventory the residual smoldering emissions were allocated to the smoldering SCCs listed in Table 2-22. The lofted smoldering emissions were assigned to the flaming emissions SCCs in Table 2-22.

Figure 2-10 is a schematic of the data processing stream for the inventory of wildfire and prescribed burn sources. The ptfire inventory sources were estimated using Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and Blue Sky Framework. SMARTFIRE2 is an algorithm and database system that operate within a geographic information system (GIS). SMARTFIRE2 combines multiple sources of fire information and reconciles them into a unified GIS database. It reconciles fire data from space-borne sensors and ground-based reports, thus drawing on the strengths of both data types while avoiding double-counting of fire events. At its core, SMARTFIRE2 is an association engine that links reports covering the same fire in any number of multiple databases. In this process, all input information is preserved, and no attempt is made to reconcile conflicting or potentially contradictory information (for example, the existence of a fire in one database but not another).

For the 2017 inventory, the national and S/L/T fire information was input into SMARTFIRE2 and then merged and associated based on user-defined weights for each fire information dataset. The output from SMARTFIRE2 was daily acres burned by fire type, and latitude-longitude coordinates for each fire. The fire type assignments were made using the fire information datasets. If the only information for a fire was a satellite detect for fire activity, then the flow described in Figure 2-11 was used to make fire type assignment by state and by month.

Figure 2-10. Processing flow for fire emission estimates in the 2017 inventory

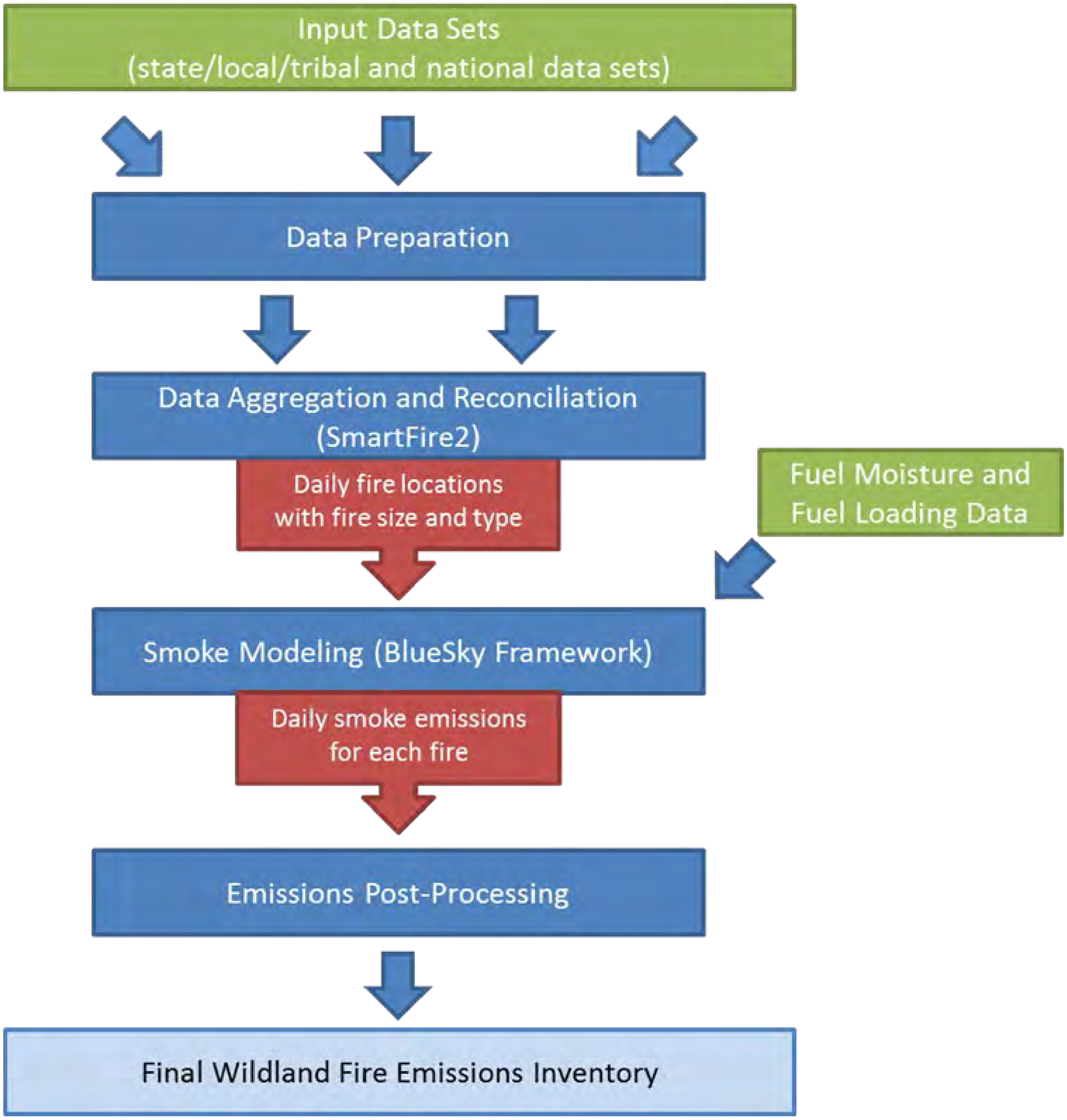
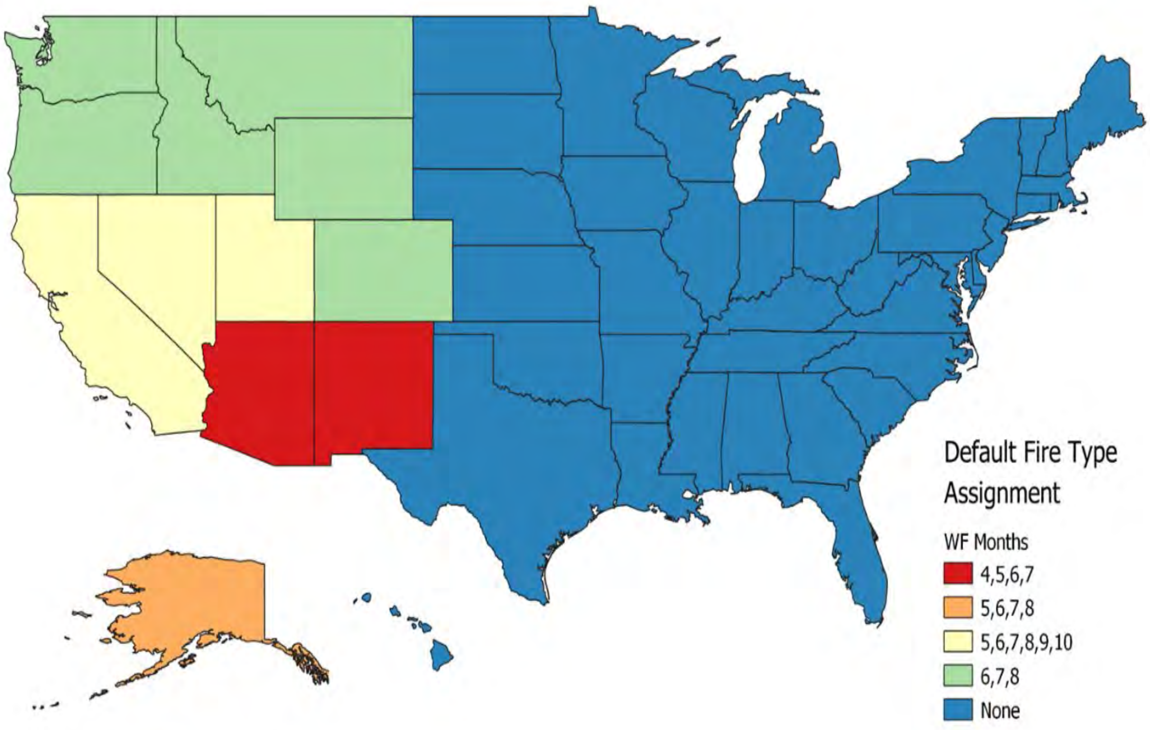
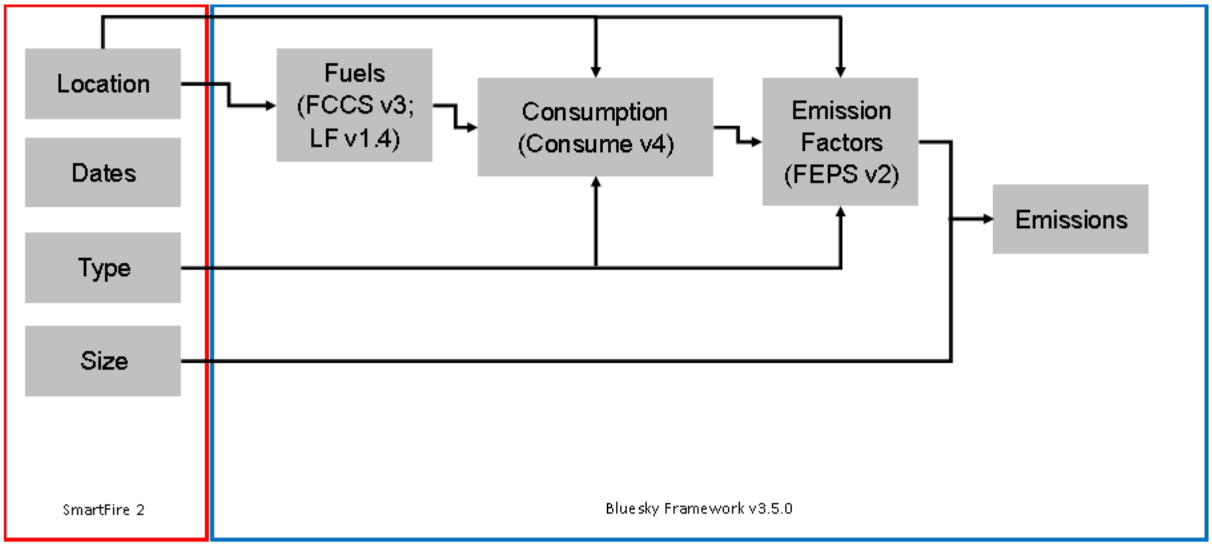


Figure 2-11. Default fire type assignment by state and month where data are only from satellites.



The second system used to estimate emissions is the BlueSky Modeling Framework version 3.5 (revision #38169). The framework supports the calculation of fuel loading and consumption, and emissions using various models depending on the available inputs as well as the desired results. The contiguous United States and Alaska, where Fuel Characteristic Classification System (FCCS) fuel loading data are available, were processed using the modeling chain described in Figure 3-2. The Fire Emissions Production Simulator (FEPS) in the BlueSky Framework generates all the CAP emission factors for wildland fires used in the 2017 inventory. HAP emission factors were obtained from Urbanski's (2014) work and applied by region and by fire type.

Figure 2-12. Blue Sky Modeling Framework



The FCCSv3 cross-reference was implemented along with the LANDFIREv1.4 (at 200 meter resolution) to provide better fuel bed information for the BlueSky Framework (BSF). The LANDFIREv1.4 was aggregated from the native resolution and projection to 200 meter using a nearest-neighbor methodology. Aggregation and reprojection was required for the proper function on BSF.

The final products from this process are annual and daily FF10-formatted emissions inventories. These SMOKE-ready inventory files contain both CAPs and HAPs. The BAFM HAP emissions from the inventory were used directly in modeling and were not overwritten with VOC speciation profiles (i.e., an "integrate HAP" use case).

2.5.2 Point source Agriculture Fires (ptagfire)

In the NEI, agricultural fires are stored as county-annual emissions and are part of the nonpoint data category. For this study agricultural fires are modeled as day specific fires derived from satellite data for the year 2017 NEI in a similar way to the emissions in ptfire. State-provided agricultural fire data from the NEI are not used in this study.

The point source agricultural fire (ptagfire) inventory sector contains daily agricultural burning emissions. Daily fire activity was derived from the NOAA Hazard Mapping System (HMS) fire activity data. The agricultural fires sector includes SCCs starting with '28015'. The first three levels of descriptions for these SCCs are: 1) Fires - Agricultural Field Burning; Miscellaneous Area Sources; 2) Agriculture Production - Crops - as nonpoint; and 3) Agricultural Field Burning - whole field set on fire. The SCC 2801500000 does not specify the crop type or burn method, while the more specific SCCs specify field or orchard crops and, in some cases, the specific crop being grown. The SCCs for this sector listed are in Table 2-23.

Table 2-23. SCCs included in the ptagfire sector

SCC	Description
2801500000	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Unspecified crop type and Burn Method

SCC	Description
2801500141	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Field Crop is Bean (red): Headfire Burning
2801500150	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Field Crop is Corn: Burning Techniques Not Important
2801500151	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Double Crop Winter Wheat and Corn
2801500152	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; DoubleCrop Corn and Soybeans
2801500160	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Field Crop is Cotton: Burning Techniques Not Important
2801500171	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Fallow
2801500220	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Field Crop is Rice: Burning Techniques Not Significant
2801500250	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Field Crop is Sugar Cane: Burning Techniques Not Significant
2801500262	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; Field Crop is Wheat: Backfire Burning
2801500263	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; DoubleCrop Winter Wheat and Cotton
2801500264	Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire; DoubleCrop Winter Wheat and Soybeans

The EPA estimated biomass burning emissions using remote sensing data. These estimates were then reviewed by the states and revised as resources allowed. As many states did not have the resources to estimate emissions for this sector, remote sensing was necessary to fill in the gaps for regions where there was no other source of data. Crop residue emissions result from either pre-harvest or post-harvest burning of agricultural fields. The crop residue emission inventory for 2017 is day-specific and includes geolocation information by crop type. The method employed and described here is based on the same methods employed in the 2017 NEI. It should be noted that grassland fires were moved from the agricultural burning inventory sector to the prescribed and wildland fire sector . This was done to prevent double-counting of fires and because there are wild grassland fires in some parts of the USA.

Daily, year-specific agricultural burning emissions were derived from HMS fire activity data, which contains the date and location of remote-sensed anomalies. As point source inventories, the locations of the fires are identified with latitude-longitude coordinates for specific fire events. The HMS activity data were filtered using 2016 USDA cropland data layer (CDL). Satellite fire detects over agricultural lands were assumed to be agricultural burns and assigned a crop type. Detects that were not over agricultural lands were output to a separate file for use in the point source wildfire (ptfire) inventory sector. Each detect was assigned an average size of between 40 and 80 acres based on crop type. The assumed field sizes are found in Table 2-24.

Table 2-24. Assumed field size of agricultural fires per state(acres)

State	Field Size
Alabama	40
Arizona	80
Arkansas	40
California	120
Colorado	80
Connecticut	40
Delaware	40
Florida	60
Georgia	40
Idaho	120
Illinois	60
Indiana	60
Iowa	60
Kansas	80
Kentucky	40
Louisiana	40
Maine	40
Maryland	40
Massachusetts	40
Michigan	40
Minnesota	60
Mississippi	40
Missouri	60
Montana	120
Nebraska	60
Nevada	40
New Hampshire	40
New Jersey	40
New Mexico	80
New York	40
North Carolina	40
North Dakota	60
Ohio	40
Oklahoma	80
Oregon	120
Pennsylvania	40
Rhode Island	40
South Carolina	40
South Dakota	60
Tennessee	40
Texas	80
Utah	40
Vermont	40
Virginia	40
Washington	120
West Virginia	40
Wisconsin	40
Wyoming	80

Another feature of the ptagfire database is that the satellite detections for 2017 were filtered out to exclude areas covered by snow during the winter months. To do this, the daily snow cover fraction per grid cell was extracted from a 2017 meteorological Weather Research Forecast (WRF) model simulation. The locations of fire detections were then compared with this daily snow cover file. For any day in which a grid cell had snow cover, the fire detections in that grid cell on that day were excluded from the inventory. Due to the inconsistent reporting of fire detections for year 2016 from the Visible Infrared Imaging Radiometer Suite (VIIRS) platform, any fire detections in the HMS dataset that were flagged as VIIRS or Suomi National Polar-orbiting Partnership satellite were excluded. In addition, certain crop types (corn and soybeans) have been excluded from these specific midwestern states: Iowa, Kansas, Indiana, Illinois, Michigan, Missouri, Minnesota, Wisconsin, and Ohio. The reason for these crop types being excluded is because states have indicated that these crop types are not burned.

Emissions factors were applied to each daily fire to calculate criteria and hazardous pollutant values. These factors vary by crop type. In all prior NEIs for this sector, the HAP emission factors and the VOC emission factors were known to be inconsistent. Corrections have been made to the application of the HAP emissions factors for the 2017 NEI. Please see section 7.4.4 in the 2017 NEI TSD for the details of the corrections.

Heat flux for plume rise was calculated using the size and assumed fuel loading of each daily agricultural fire. This information is needed for a plume rise calculation within a chemical transport modeling system.

The daily agricultural and open burning emissions were converted from a tabular format into the SMOKE-ready daily point flat file format. The daily emissions were also aggregated into annual values by location and converted into the annual point flat file format.

The state of Georgia provided their own estimates of agricultural crop residue burning and completely replaced the emission estimates by the EPA. The HMS information was replaced with the state-supplied activity data and the emissions were recomputed for this state. See section 4.12 in 2017 NEI TSD for more details on agricultural crop residue burning.

For this modeling platform, a SMOKE update allows the use of HAP integration for speciation for PTDAY inventories. The 2017 agricultural fire inventories include emissions for HAPs, so HAP integration was used for this study.

2.6 Biogenic Sources (beis)

Biogenic emissions were computed based on the 17j version of the 2017 meteorology data used for the air quality modeling and were developed using the Biogenic Emission Inventory System version 3.7 (BEIS3.7) within CMAQ. The BEIS3.7 creates gridded, hourly, model-species emissions from vegetation and soils. It estimates CO, VOC (most notably isoprene, terpene, and sesquiterpene), and NO emissions for the contiguous U.S. and for portions of Mexico and Canada. In the BEIS 3.7 two-layer canopy model, the layer structure varies with light intensity and solar zenith angle (Pouliot and Bash, 2015). Both layers include estimates of sunlit and shaded leaf area based on solar zenith angle and light intensity, direct and diffuse solar radiation, and leaf temperature (Bash et al., 2015). The new algorithm requires additional meteorological variables over previous versions of BEIS.

BEIS3.7 was used in conjunction with Version 5 of the Biogenic Emissions Landuse Database (BELD5). The BELD5 is based on an updated version of the USDA-USFS Forest Inventory and Analysis (FIA) vegetation speciation-based data from 2001 to 2017 from the FIA version 8.0. Canopy coverage is based on the Global Moderate Resolution Imaging Spectroradiometer (MODIS) 20 category data with enhanced lakes and Fraction of Photosynthetically Active Radiation (FPAR) for vegetation coverage from National Center for Atmospheric Research (NCAR). The FIA includes approximately 250,000 representative plots of species fraction data that are within approximately 75 km of one another in areas identified as forest by the MODIS canopy coverage. For land areas outside the conterminous United States, 500 meter grid spacing land cover data from the Moderate Resolution Imaging Spectroradiometer (MODIS) is used. BELDv5 also incorporates the following datasets:

- Newer version of the Forest Inventory and Analysis (FIA version 8.0 https://www.fia.fs.fed.us/library/database-documentation/index.php)
- Agricultural land use from the 2017 US Department of Agriculture (USDA) crop data layer (https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php)
- Global Moderate Resolution Imaging Spectroradiometer (MODIS) 20 category data with enhanced lakes and Fraction of Photosynthetically Active Radiation (FPAR) for vegetation coverage from National Center for Atmospheric Research (NCAR) (https://www2.mmm.ucar.edu/wrf/users/download/get_sources_wps_geog.html)
    - Note BELD4.1 used 2011 USGS National Land Cover Data (NLCD) limited to the USA and MODIS 20 category land use for the rest of the world.
- Canadian BELD land use (https://www.epa.gov/sites/default/files/2019-08/documents/800am_zhang_2_0.pdf).

The FIA database reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. The FIA database version 8.0 includes recent updates of these data through the year 2017 (from 2001). Earlier versions of BELD used an older version of the FIA database that had included data only through the year 2014. Canopy coverage is based on the MODIS 20 category data. The FIA includes approximately 250,000 representative plots of species fraction data that are within approximately 75 km of one another in areas identified as forest by the MODIS canopy coverage. For all land areas in the United States, 500-meter grid spacing land cover data from the MODIS is used.

Like BELD4, the processing of the BELD5 data follows the spatial allocation methods of Bash et al. 2016. However, MODIS land use categories and FPAR are used in the place of NLCD land use and forest coverage. MODIS land use has the additional broadleaf evergreen and deciduous needleleaf land use types and only one developed land use type. BELD4.1 used lookup tables for species leaf biomass. In BELD5, allometric relationships from the FIA v8.0 database (https://www.fia.fs.fed.us/library/database-documentation/index.php) were utilized to estimate foliage biomass per species. This resulted in better agreement with measured foliage biomass. BVOC emissions are understood to originate from foliage thus these biomass changes directly impacted the BEIS emission factors.

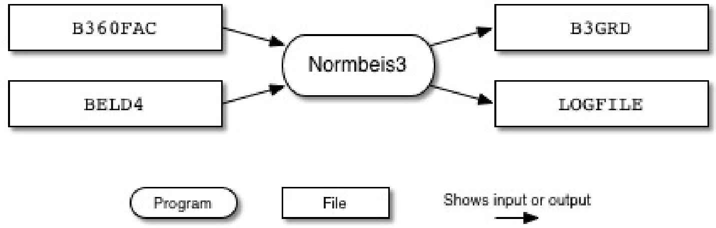
BEIS3.7 has some important updates from BEIS 3.61. These include the incorporation BELD5 and updates to biomass emissions factors. BEIS3.7 includes a two-layer canopy model. Layer structure varies with light intensity and solar zenith angle. Both layers of the canopy model include estimates of sunlit and shaded leaf area based on solar zenith angle and light intensity, direct and diffuse solar radiation, and leaf temperature (Bash et al., 2016). The new algorithm requires additional meteorological variables over previous versions of BEIS. The variables output from the Meteorology-Chemistry Interface Processor (MCIP) that are used for BEIS3.7 processing are shown in Table 2-25. The BEIS3 modeling for year 2017 included processing for a 12km domain (12US1) (see Figure 3-1). The 12US2 modeling domain can also be supported by taking a subset or window of the 12US1 BEIS3 emissions dataset.

Table 2-25. Hourly Meteorological variables required by BEIS 3.7

Variable	Description
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2 m
RC	convective precipitation
RGRND	solar radiation reaching surface
RN	non-convective precipitation
RSTOMI	inverse of bulk stomatal resistance
SLYTP	soil texture type by USDA category
SOIM1	volumetric soil moisture in top cm
SOIT1	soil temperature in top cm
TEMPG	skin temperature at ground
USTAR	cell averaged friction velocity
RADYNI	inverse of aerodynamic resistance
TEMP2	temperature at 2 m

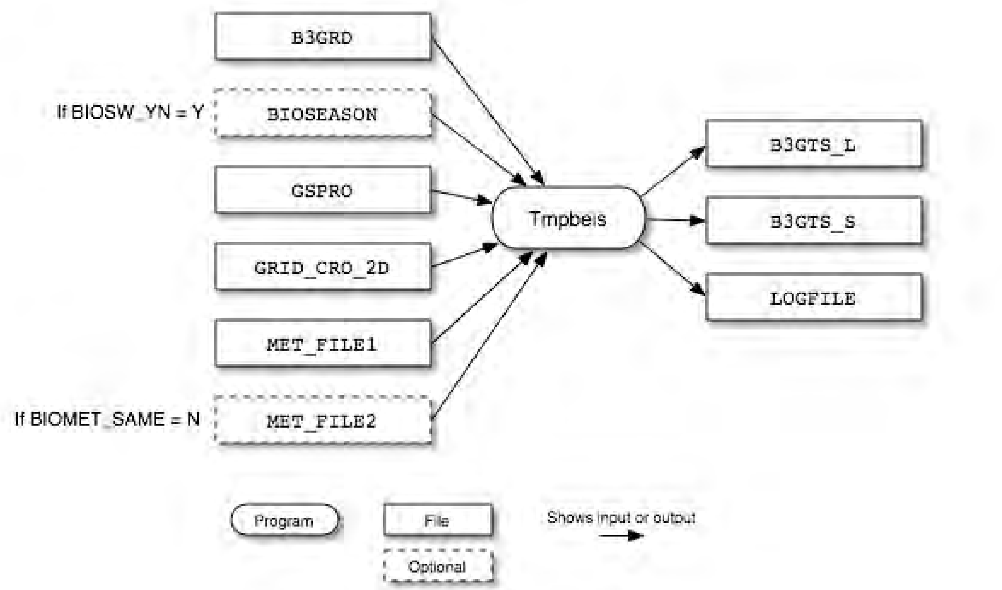
SMOKE-BEIS3 modeling system consists of two programs named: 1) Normbeis3 and 2) Tmpbeis3. Normbeis3 uses emissions factors and BELD5 landuse to compute gridded normalized emissions for chosen model domain (see Figure 2-13). The emissions factor file contains leaf-area-indices (LAI), dry leaf biomass, winter biomass factor, indicator of specific leaf weight, and normalized emission fluxes for 35 different species/compounds. The BELD5 file is the gridded landuse for 200+ different landuse types. The output gridded domain is the same as the input domain for the land use data. Output emission fluxes (B3GRD) are normalized to 30 °C, and isoprene and methyl-butenol fluxes are also normalized to a photosynthetic active radiation of 1000 µmol/m^{2}s.

Figure 2-13. Normbeis3 data flows



The normalized emissions output from Normbeis3 (B3GRD) are input into Tmpbeis3 along with the MCIP meteorological data, chemical speciation profile to use for desired chemical mechanism, and BIOSEASON file used to indicate how each day in the year being modeled should be treated, either as summer or winter. Figure 2-14 illustrates the data flows for the Tmpbeis3 program. The output from Tmpbeis includes gridded, speciated, hourly emissions both in moles/second (B3GTS_L) and tons/hour (B3GTS_S).

Figure 2-14. Tmpbeis3 data flow diagram.



Biogenic emissions do not use an emissions inventory and do not have SCCs. The gridded land use data, gridded meteorology, an emissions factor file, and a speciation profile are further described in the speciation section.

Biogenic emissions computed with BEIS were left out of the CMAQ-ready merged emissions in favor of inline biogenics produced during the CMAQ model run itself using the same algorithm described above but with finer time steps within the air quality model.

2.7 Sources Outside of the United States

The emissions from Canada and Mexico are included as part of the emissions modeling sectors: othpt, othar, othafdust, othptdust, onroad_can, and onroad_mex. The "oth" refers to the fact that these emissions are usually "other" than those in the U.S. state-county geographic FIPS, and the remaining characters provide the SMOKE source types: "pt" for point, "ar" for area and nonroad mobile, "afdust" for area fugitive dust (Canada only), and "ptdust" for point fugitive dust (Canada only). The onroad emissions for Canada and Mexico are in the onroad_can and onroad_mex sectors, respectively.

Environment and Climate Change Canada (ECCC) provided a set of inventories for the year 2015. ECCC also provided data for the year 2023, either in the form of standalone inventories, or projection factors to apply to the 2015 data. Those 2015 and 2023 inventories were interpolated to the year 2017 for all Canadian inventories used in this study except for fires and CMV.

ECCC provided the following 2015 inventories for use in this study:

- Agricultural livestock and fertilizer, point source format (othpt sector)
- Agricultural fugitive dust, point source format (othptdust sector)
- Other area source dust (othafdust sector)
- Airports, point source format (othpt sector)
- Onroad (onroad_can sector)
- Nonroad and rail (othar sector)
- CMV, provided as area sources but converted to point (othpt sector)
- Other area sources (othar sector)
- Other point sources, including oil and gas (othpt sector)

ECCC provided all CMV emissions as an area source inventory. The 2017 NEI CMV included most coastal waters of Canada and Mexico with emissions derived from AIS data. These NEI emissions were used for all areas of Canada and Mexico in which they were available and are included in the cmv_c1c2 and cmv_c3 sectors. Both the C1C2 and C3 emissions were developed in a point source format with points at the center of the 12km grid cells. Activity and corresponding emissions along the St. Lawrence Seaway were not included in the NEI. This region was gapfilled with emissions provided by ECCC that were apportioned to point sources on the centroids of 12km grid cells using the Canadian commercial marine vessel surrogate (CA 945).

In addition to emissions inventories, the ECCC 2015 dataset also included temporal profiles, and shapefiles for creating spatial surrogates. These updated profiles and surrogates were used for this study. Other than the CB6 species of NBAFM present in the speciated point source data, there are no explicit HAP emissions in these Canadian inventories.

2.7.1 Point Sources in Canada and Mexico (othpt)

Canadian point source inventories were interpolated to 2017 between 2015 and 2023 emission levels. These inventories include emissions for airports and other point sources. One of the Canadian point source inventories in the othpt sector includes pre-speciated VOC emissions for the CB6 mechanism. However, this inventory did not include all species needed for the CB6 mechanism for CMAQ; specifically, CH4, SOAALK, NAPH, and XYLMN were missing. For the NAPH species, naphthalene emissions from a supplemental HAP inventory provided by ECCC were used. Then, XYL was converted to XYLMN by subtracting NAPH. Finally, CH4 and SOAALK were speciated from total VOC (also provided by ECCC) using traditional speciation profiles by SCC. There are also other sources in Canada, such as oil and gas, for which we do not have pre-speciated VOC emissions and for which we apply VOC speciation within SMOKE.

Point sources in Mexico were compiled based on inventories projected from the Inventario Nacional de Emisiones de Mexico, 2016 (Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT)). The point source emissions were converted to English units and into the FF10 format that could be read by SMOKE, missing stack parameters were gapfilled using SCC-based defaults, and latitude and longitude coordinates were verified and adjusted if they were not consistent with the reported municipality. Only CAPs are covered in the Mexico point source inventory.

2.7.2 Fugitive Dust Sources in Canada (othafdust, othptdust)

Canadian fugitive dust inventories from tilling and harvest were interpolated to 2017 between 2015 and 2023 emission levels. The Canadian inventory included fugitive dust emissions that do not incorporate either a transportable fraction or meteorological-based adjustments. To properly account for this, a separate sector called othafdust (for area sources) and othptdust (for point sources) were created and modeled using the same adjustments as are done for U.S. sources. Since fugitive dust emissions were provided in both area and point format, these emissions needed to be processed as through SMOKE two separate sectors, one for area sources and one for point sources.

A transport fraction adjustment that reduces dust emissions based on land cover types was applied to both point and nonpoint dust emissions, along with a meteorology-based (precipitation and snow/ice cover) zero-out of emissions when the ground is snow covered or wet.

2.7.3 Nonpoint and Nonroad Sources in Canada and Mexico (othar)

Canadian inventories for nonpoint sources and nonroad sources were interpolated to 2017 between 2015 and 2023 emission levels. These inventories include rail emissions and other nonroad sources, along with livestock ammonia and VOC emissions.

For Mexican area and nonroad sources, emission projections based on Mexico's 2016 inventory were used for area, point and nonroad sources (Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT)). The resulting inventory was written using English units to the nonpoint FF10 format that could be read by SMOKE. Note that unlike the U.S. inventories, there are no explicit HAPs in the nonpoint or nonroad inventories for Canada and Mexico and, therefore, all HAPs are created from speciation. Similar to the point inventories, Mexican area and nonroad inventories were projected from 2008 to the years 2014 and 2018, and then emissions values were interpolated to year 2016 values for this study.

2.7.4 Onroad Sources in Canada and Mexico (onroad_can, onroad_mex)

Canadian inventories for onroad sources were interpolated to 2017 between 2015 and 2023 levels. Emissions inventories were provided for refueling and other onroad emissions.

For Mexico onroad emissions, a version of the MOVES model for Mexico was run that provided the same VOC HAPs and speciated VOCs as for the U.S. MOVES model (ERG, 2016a). This includes NBAFM plus several other VOC HAPs such as toluene, xylene, ethylbenzene and others. Except for VOC HAPs that are part of the speciation, no other HAPs are included in the Mexico onroad inventory (such as particulate HAPs nor diesel particulate matter). Mexico onroad inventories were generated by MOVES for the years 2014 and 2017.

2.7.5 Fires in Canada and Mexico (*ptfire_othna*)

Annual 2017 wildland emissions for Mexico, Canada, Central America, and Caribbean nations are included in the ptfire_othna sector. Canadian fires, along with fires in Mexico, Central America, and the Caribbean, were developed from Fire Inventory from NCAR (FINN) 2017 v1.5 daily fire emissions. For FINN fires, listed vegetation type codes of 1 and 9 are defined as agricultural burning, all other fire detections and assumed to be wildfires. All wildland fires that are not defined as agricultural are assumed to be wildfires rather than prescribed. FINN fire detects of less than 50 square meters (0.012 acres) are removed from the inventory. The locations of FINN fires are geocoded from latitude and longitude to FIPS code.

For FINN fires, listed vegetation type codes of 1 and 9 are defined as agricultural burning, all other fire detections and assumed to be wildfires. All wildland fires that are not defined as agricultural are assumed to be wildfires rather than prescribed. FINN fire detects less than 50 square meters (0.012 acres) are removed from the inventory. The locations of FINN fires are geocoded from latitude and longitude to FIPS code.

2.7.6 Ocean Chlorine, Ocean Sea Salt, and Volcanic Mercury

The ocean chlorine gas emission estimates are based on the build-up of molecular chlorine (Cl_2) concentrations in oceanic air masses (Bullock and Brehme, 2002). Data at 36 km and 12 km resolution were available and were not modified other than the model-species name "CHLORINE" was changed to "CL2" to support CMAQ modeling. The CL2 emissions are constant in all ocean grid cells. These data are unchanged from the data in 2016v1 and are passed to both CMAQ and CAMx. Separately from the ocean chlorine, CMAQ computes sea salt particulate emissions inline during the model run.

For mercury, the same volcanic mercury emissions were used as in the last several modeling platforms. The emissions were originally developed for a 2002 multipollutant modeling platform with coordination and data from Christian Seigneur and Jerry Lin for 2001 (Seigneur et. al, 2004 and Seigneur et. al, 2001).

Because of mercury bidirectional flux within the latest version of CMAQ, the only natural mercury emissions included in the merge are from volcanoes.

3 Emissions Modeling

The CMAQ and CAMx air quality models require hourly emissions of specific gas and particle species for the horizontal and vertical grid cells contained within the modeled region (i.e., modeling domain). To provide emissions in the form and format required by the model, it is necessary to "pre-process" the "raw" emissions (i.e., emissions input to SMOKE) for the sectors described above in Section 2. In brief, the process of emissions modeling transforms the emissions inventories from their original temporal resolution, pollutant resolution, and spatial resolution into the hourly, speciated, gridded and vertical resolution required by the air quality model. Emissions modeling includes temporal allocation, spatial allocation, and pollutant speciation. Emissions modeling sometimes includes the vertical allocation (i.e., plume rise) of point sources, but many air quality models also perform this task because it greatly reduces the size of the input emissions files if the vertical layers of the sources are not included.

As seen in Section 2, the temporal resolutions of the emissions inventories input to SMOKE vary across sectors and may be hourly, daily, monthly, or annual total emissions. The spatial resolution may be individual point sources; totals by county (U.S.), province (Canada), or municipio (Mexico); or gridded emissions. This section provides some basic information about the tools and data files used for emissions modeling as part of the modeling platform.

3.1 Emissions Modeling Overview

SMOKE version 4.7 was used to process the raw emissions inventories into emissions inputs for each modeling sector into a format compatible with CMAQ. SMOKE executables and source code are available from the Community Multiscale Analysis System (CMAS) Center at http://www.cmascenter.org. Additional information about SMOKE is available from http://www.smoke-model.org. For sectors that have plume rise, the in-line plume rise capability allows for the use of emissions files that are much smaller than full three-dimensional gridded emissions files. For quality assurance of the emissions modeling steps, emissions totals by specie for the entire model domain are output as reports that are then compared to reports generated by SMOKE on the input inventories to ensure that mass is not lost or gained during the emissions modeling process.

When preparing emissions for the air quality model, emissions for each sector are processed separately through SMOKE, and then the final merge program (Mrggrid) is run to combine the model-ready, sector-specific 2-D gridded emissions across sectors. The SMOKE settings in the run scripts and the data in the SMOKE ancillary files control the approaches used by the individual SMOKE programs for each sector. Table 3-1 summarizes the major processing steps of each platform sector with the columns as follows.

The "Spatial" column shows the spatial approach used: "point" indicates that SMOKE maps the source from a point location (i.e., latitude and longitude) to a grid cell; "surrogates" indicates that some or all of the sources use spatial surrogates to allocate county emissions to grid cells; and "area-to-point" indicates that some of the sources use the SMOKE area-to-point feature to grid the emissions (further described in Section 3.4.2).

The "Speciation" column indicates that all sectors use the SMOKE speciation step, though biogenics speciation is done within the Tmpbeis3 program and not as a separate SMOKE step.

The "Inventory resolution" column shows the inventory temporal resolution from which SMOKE needs to calculate hourly emissions. Note that for some sectors (e.g., onroad, beis), there is no input inventory;

instead, activity data and emission factors are used in combination with meteorological data to compute hourly emissions.

Finally, the “plume rise” column indicates the sectors for which the “in-line” approach is used. These sectors are the only ones with emissions in aloft layers based on plume rise. The term “in-line” means that the plume rise calculations are done inside of the air quality model instead of being computed by SMOKE. In all of the “in-line” sectors, all sources are output by SMOKE into point source files which are subject to plume rise calculations in the air quality model. In other words, no emissions are output to layer 1 gridded emissions files from those sectors as has been done in past platforms. The air quality model computes the plume rise using stack parameters, the Briggs algorithm, and the hourly emissions in the SMOKE output files for each emissions sector. The height of the plume rise determines the model layers into which the emissions are placed. The plume top and bottom are computed, along with the plumes’ distributions into the vertical layers that the plumes intersect. The pressure difference across each layer divided by the pressure difference across the entire plume is used as a weighting factor to assign the emissions to layers. This approach gives plume fractions by layer and source. Day-specific point fire emissions are treated differently in CMAQ. After plume rise is applied, there are emissions in every layer from the ground up to the top of the plume.

Table 3-1. Key emissions modeling steps by sector.

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
afdust_adj	Surrogates	Yes	Annual	
ag	Surrogates	Yes	annual	
airports	Point	Yes	Annual	None
beis	Pre-gridded land use	in BEIS3.7	computed hourly	
cmv_c1c2	Point	Yes	hourly	in-line
cmv_c3	Point	Yes	hourly	in-line
nonpt	Surrogates & area-to-point	Yes	Annual	
nonroad	Surrogates	Yes	monthly	
np_oilgas	Surrogates	Yes	Annual	
onroad	Surrogates	Yes	monthly activity, computed hourly	
onroad_ca_adj	Surrogates	Yes	monthly activity, computed hourly	
onroad_can	Surrogates	Yes	monthly	
onroad_mex	Surrogates	Yes	monthly	
othafdust_adj	Surrogates	Yes	annual	
othar	Surrogates	Yes	annual & monthly	

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
othpt	Point	Yes	annual & monthly	in-line
othptdust_adj	Point	Yes	monthly	None
ptagfire	Point	Yes	daily	in-line
pt_oilgas	Point	Yes	annual	in-line
ptegu	Point	Yes	daily & hourly	in-line
ptfire	Point	Yes	daily	in-line
ptfire_othna	Point	Yes	daily	in-line
ptnonipm	Point	Yes	annual	in-line
rail	Surrogates	Yes	annual	
rwc	Surrogates	Yes	annual	

Note that SMOKE has the option of grouping sources so that they are treated as a single stack when computing plume rise. For the modeling cases discussed in this document, no grouping was performed because grouping combined with "in-line" processing will not give identical results as "offline" processing (i.e., when SMOKE creates 3-dimensional files). This occurs when stacks with different stack parameters or latitude and longitudes are grouped, thereby changing the parameters of one or more sources. The most straightforward way to get the same results between in-line and offline is to avoid the use of stack grouping.

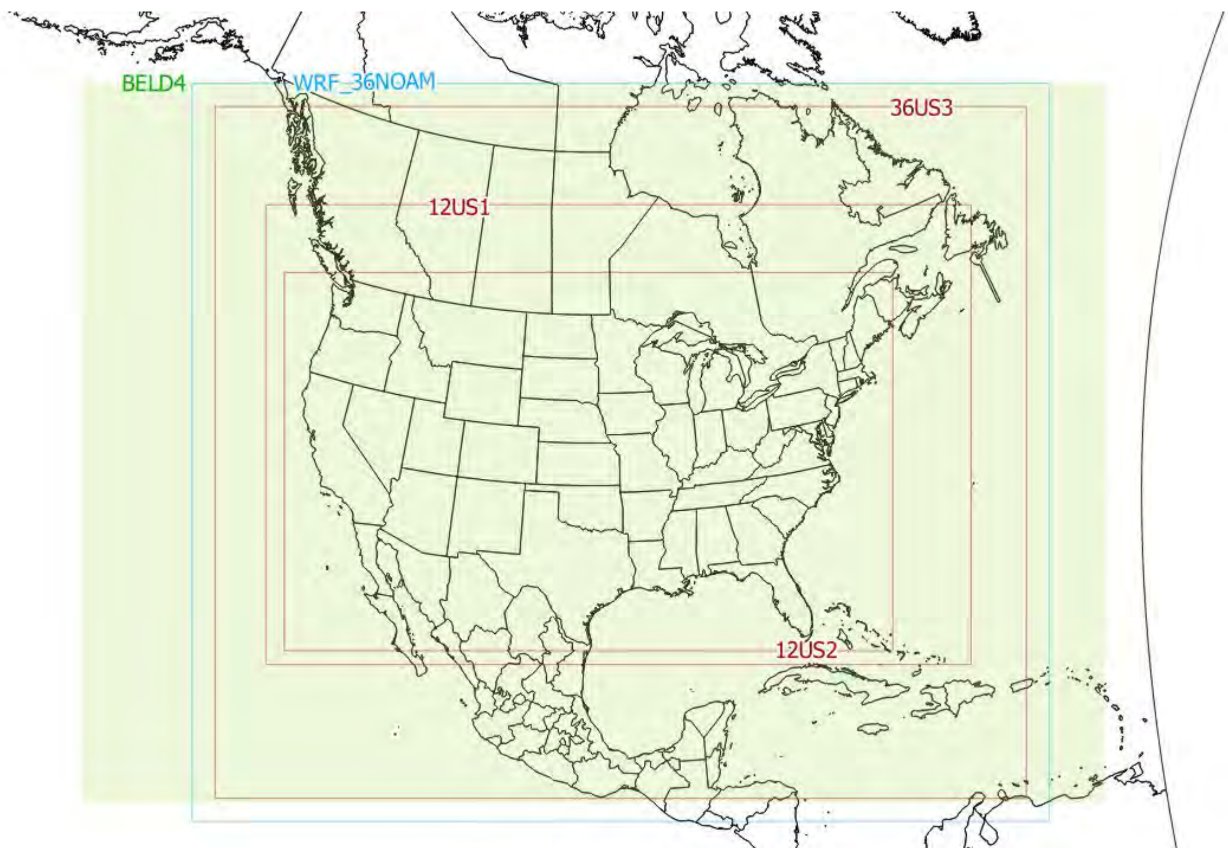
Biogenic emissions can be modeled two different ways in the CMAQ model. The BEIS model in SMOKE can produce gridded biogenic emissions that are then included in the gridded CMAQ-ready emissions inputs, or alternatively, CMAQ can be configured to create "in-line" biogenic emissions within CMAQ itself. For this platform, biogenic emissions were processed in SMOKE and included in the gridded CMAQ-ready emissions. When CAMx is the targeted air quality model, BEIS is run within SMOKE and the resulting emissions are included with the ground-level emissions input to CAMx.

Emissions were developed for the 12-km resolution domain 12US2. More specifically, SMOKE was run on the 12US1 domain and emissions were extracted from 12US1 data files to create 12US2 emission. The domains are shown in Figure 3-1. All grids use a Lambert-Conformal projection, with Alpha = 33º, Beta = 45º and Gamma = -97º, with a center of X = -97º and Y = 40º. Table 3-2 describes the grids for the three domains.

Table 3-2. Descriptions of the platform grids

Common Name	Grid Cell Size	Description (see Figure 3-1)	Grid name	Parameters listed in SMOKE grid description (GRIDDESC) file: projection name, xorig, yorig, xcell, ycell, ncols, nrows, nthik
Continental 36km grid	36 km	Entire conterminous US, almost all of Mexico, most of Canada (south of 60°N)	36US3	'LAM_40N97W', -2952000, -2772000, 36.D3, 36.D3, 172, 148, 1
Continental 12km grid	12 km	Entire conterminous US plus some of Mexico/Canada	12US1_459X299	'LAM_40N97W', -2556000, -1728000, 12.D3, 12.D3, 459, 299, 1
US 12 km or "smaller" CONUS-12	12 km	Smaller 12km CONUS plus some of Mexico/Canada	12US2	'LAM_40N97W', -2412000 , -1620000, 12.D3, 12.D3, 396, 246, 1

Figure 3-1. Air quality modeling domains



3.2 Chemical Speciation

The emissions modeling step for chemical speciation creates the "model species" needed by the air quality model for a specific chemical mechanism. These model species are either individual chemical compounds (i.e., "explicit species") or groups of species (i.e., "lumped species"). The chemical mechanism used for the 2017 platform is the CB6R3AE7 mechanism (Yarwood, 2010, Luecken, 2019). In CB6R3AE7 the species added compared to older versions of CB6 are acetic acid (AACD), acetone (ACET), alpha pinene (APIN), formic acid (FACD), naphthalene (NAPH), and intermediate volatility organic compounds (IVOC; $3x10^2$ μg m^{-3} < C* < $3x10^6$ μg m^{-3}; note C* is the saturation vapor pressure). This mapping uses a new systematic methodology for mapping low volatility compounds. Compounds with very low volatility (C* < $3x10^2$ μg m^{-3}) are mapped to model species NVOL. In previous mappings, some of these low vapor pressure compounds were mapped to CB6 species. The mechanism and mapping are described in more detail in a memorandum describing the mechanism files supplied with the Speciation Tool, the software used to create the CB6 profiles used in SMOKE. It should be noted that the onroad mobile sector does not use this newer mapping because the speciation is done within MOVES and the mapping change was made after MOVES had been run. This platform generates the $PM_{2.5}$ model species associated with the CMAQ Aerosol Module version 7 (AE7).

Table 3-3 lists the model species produced by SMOKE in the CMAQ platform used for this study[16]. Updates to species assignments for CB05 and CB6 were made for the 2014v7.1 platform and are described in Appendix A. Table 3-4 and Table 3-5 list additional CMAQ model species generated specifically for HAP toxics modeling. Pollutants groups exist for chromium VI (hexavalent), cresol cresylic acid (mixed isomers), cynanide compounds, glycol ethers, nickel compounds, PAHPOM, polychlorinated biphenyls (aroclors), and xylenes (mixed isomers). Table 3-6 lists a mapping of polycyclic aromatic hydrocarbons (PAHs) to the PAH groups used in CMAQ modeling.

Table 3-3. Emission model species produced for CB6R3AE7 for CMAQ

Inventory Pollutant	Model Species	Model species description
Cl_2	CL2	Atomic gas-phase chlorine
HCl	HCL	Hydrogen Chloride (hydrochloric acid) gas
CO	CO	Carbon monoxide
NO_X	NO	Nitrogen oxide
NO_X	NO2	Nitrogen dioxide
NO_X	HONO	Nitrous acid
SO_2	SO2	Sulfur dioxide
SO_2	SULF	Sulfuric acid vapor
NH_3	NH3	Ammonia
NH_3	NH3_FERT	Ammonia from fertilizer
VOC	AACD	Acetic acid
VOC	ACET	Acetone
VOC	ALD2	Acetaldehyde
VOC	ALDX	Propionaldehyde and higher aldehydes
VOC	APIN	Alpha pinene
VOC	BENZ	Benzene (not part of CB05)
VOC	CH4	Methane

[16] This table includes the NBAFM species because they are generated through VOC speciation for sectors with no HAP inventories (e.g. Canada) although these species will not be generated through speciation for most sectors.

Inventory Pollutant	Model Species	Model species description
VOC	ETH	Ethene
VOC	ETHA	Ethane
VOC	ETHY	Ethyne
VOC	ETOH	Ethanol
VOC	FACD	Formic acid
VOC	FORM	Formaldehyde
VOC	IOLE	Internal olefin carbon bond (R-C=C-R)
VOC	ISOP	Isoprene
VOC	IVOC	Intermediate volatility organic compounds
VOC	KET	Ketone Groups
VOC	MEOH	Methanol
VOC	NAPH	Naphthalene
VOC	NVOL	Non-volatile compounds
VOC	OLE	Terminal olefin carbon bond (R-C=C)
VOC	PAR	Paraffin carbon bond
VOC	PRPA	Propane
VOC	SESQ	Sesquiterpenes (from biogenics only)
VOC	SOAALK	Secondary Organic Aerosol (SOA) tracer
VOC	TERP	Terpenes (from biogenics only)
VOC	TOL	Toluene and other monoalkyl aromatics
VOC	UNR	Unreactive
VOC	XYLMN	Xylene and other polyalkyl aromatics, minus naphthalene
Naphthalene	NAPH	Naphthalene from inventory
Benzene	BENZ	Benzene from the inventory
Acetaldehyde	ALD2	Acetaldehyde from inventory
Formaldehyde	FORM	Formaldehyde from inventory
Methanol	MEOH	Methanol from inventory
PM_{10}	PMC	Coarse PM > 2.5 microns and ≤ 10 microns
$PM_{2.5}$	PEC	Particulate elemental carbon ≤ 2.5 microns
$PM_{2.5}$	PNO3	Particulate nitrate ≤ 2.5 microns
$PM_{2.5}$	POC	Particulate organic carbon (carbon only) ≤ 2.5 microns
$PM_{2.5}$	PSO4	Particulate Sulfate ≤ 2.5 microns
$PM_{2.5}$	PAL	Aluminum
$PM_{2.5}$	PCA	Calcium
$PM_{2.5}$	PCL	Chloride
$PM_{2.5}$	PFE	Iron
$PM_{2.5}$	PK	Potassium
$PM_{2.5}$	PH2O	Water
$PM_{2.5}$	PMG	Magnesium
$PM_{2.5}$	PMN	Manganese
$PM_{2.5}$	PMOTHR	$PM_{2.5}$ not in other AE6 species
$PM_{2.5}$	PNA	Sodium
$PM_{2.5}$	PNA	Sodium
$PM_{2.5}$	PNCOM	Non-carbon organic matter

Inventory Pollutant	Model Species	Model species description
$PM_{2.5}$	PNH4	Ammonium
$PM_{2.5}$	PSI	Silica
$PM_{2.5}$	PTI	Titanium

Table 3-4. Additional HAP Gaseous model species produced for CMAQ multipollutant specifically for toxics modeling (not used within CB6)

Inventory Pollutant	Model Species
Acetaldehyde	ALD2_PRIMARY
Formaldehyde	FORM_PRIMARY
Acetonitrile	ACETONITRILE
Acrolein	ACROLEIN
Acrylic acid	ACRYLICACID
Acrylonitrile	ACRYLONITRILE
Benzo[a]Pyrene	BENZOAPYRNE
1,3-Butadiene	BUTADIENE13
Carbon tetrachloride	CARBONTET
Carbonyl Sulfide	CARBSULFIDE
Chloroform	CHCL3
Chloroprene	CHLOROPRENE
1,4-Dichlorobenzene(p)	DICHLOROBENZENE
1,3-Dichloropropene	DICHLOROPROPENE
Ethylbenzene	ETHYLBENZ
Ethylene dibromide (Dibromoethane)	BR2_C2_12
Ethylene dichloride (1,2-Dichloroethane)	CL2_C2_12
Ethylene oxide	ETOX
Hexamethylene-1,6-diisocyanate	HEXAMETH_DIIS
Hexane	HEXANE
Hydrazine	HYDRAZINE
Maleic Anyhydride	MAL_ANYHYDRIDE
Methyl Chloride	METHCLORIDE
Methylene chloride (Dichloromethane)	CL2_ME
Specific PAHs assigned with URE =0	PAH_000E0
Specific PAHs assigned with URE =9.6E-06 (previously 1.76E-5)	PAH_176E5
Specific PAHs assigned with URE =4.8E-05 (previously 8.8E-5)	PAH_880E5
Specific PAHs assigned with URE =9.6E-05 (previously 1.76E-4)	PAH_176E4
Specific PAHs assigned with URE =9.6E-04 (previously 1.76E-3)	PAH_176E3
Specific PAHs assigned with URE =9.6E-03 (previously 1.76E-2)	PAH_176E2
Specific PAHs assigned with URE =0.01 (previously 1.01E-2)	PAH_101E2
Specific PAHs assigned with URE =1.14E-1	PAH_114E1
Specific PAHs assigned with URE =9.9E-04 (previously 1.92E-3)	PAH_192E3
Propylene dichloride (1,2-Dichloropropane)	PROPDICHLORIDE
Quinoline	QUINOLINE
Styrene	STYRENE
1,1,2,2-Tetrachloroethane	CL4_ETHANE1122
Tetrachloroethylene (Perchloroethylene)	CL4_ETHE
Toluene	TOLU
2,4-Toluene diisocyanate	TOL_DIIS
Trichloroethylene	CL3_ETHE
Triethylamine	TRIETHYLAMINE
m-xylene, o-xylene, p-xylene, xylenes (mixed isomers)	XYLENES
Vinyl chloride	CL_ETHE

Table 3-5. Additional HAP Particulate* model species produced for CMAQ multipollutant modeling

Inventory Pollutant	Model Species
Arsenic	ARSENIC_C, ARSENIC_F
Beryllium	BERYLLIUM_C, BERYLLIUM_F
Cadmium	CADMIUM_C, CADMIUM_F
Chromium VI, Chromic Acid (VI), Chromium Trioxide	CHROMHEX_C, CHROMHEX_F
Chromium III	CHROMTRI_C, CHROMTRI_F
Lead	LEAD_C, LEAD_F
Manganese	MANGANESE_C, MANGANESE_F
Mercury[1]	HGIIGAS, HGNRVA, PHGI
Nickel, Nickel Oxide, Nickel Refinery Dust	NICKEL_C, NICKEL_F
Diesel-PM10, Diesel-PM25	DIESEL_PMC , DIESEL_PMFINE, DIESEL_PMEC, DIESEL_PMOC, DIESEL_PMNO3, DIESEL_PMSO4

[1]Mercury is multi-phase

Table 3-6. PAH/POM pollutant groups

PAH Group	NEI Pollutant Code	NEI Pollutant Description	URE 1/(µg/m^3)
PAH_000E0	120127	Anthracene	0
PAH_000E0	129000	Pyrene	0
PAH_000E0	85018	Phenanthrene	0
PAH_101E2	56495	3-Methylcholanthrene	0.01
PAH_114E1	57976	7,12-Dimethylbenz[a]Anthracene	0.114
PAH_176E2	189559	Dibenzo[a,i]Pyrene	9.6E-03
PAH_176E2	189640	Dibenzo[a,h]Pyrene	9.6E-03
PAH_176E2	191300	Dibenzo[a,l]Pyrene	9.6E-03
PAH_176E3	192654	Dibenzo[a,e]Pyrene	9.6E-04
PAH_176E3	194592	7H-Dibenzo[c,g]carbazole	9.6E-04
PAH_176E3	3697243	5-Methylchrysene	9.6E-04
PAH_176E3	41637905	Methylchrysene	9.6E-04
PAH_176E3	53703	Dibenzo[a,h]Anthracene	9.6E-04
PAH_176E4	193395	Indeno[1,2,3-c,d]Pyrene	9.6E-05
PAH_176E4	205823	Benzo[j]Fluoranthene	9.6E-05
PAH_176E4	205992	Benzo[b]Fluoranthene	9.6E-05
PAH_176E4	224420	Dibenzo[a,j]Acridine	9.6E-05
PAH_176E4	226368	Dibenz[a,h]acridine	9.6E-05
PAH_176E4	5522430	1-Nitropyrene	9.6E-05
PAH_176E4	56553	Benz[a]Anthracene	9.6E-05
PAH_176E5	207089	Benzo[k]Fluoranthene	9.6E-06
PAH_176E5	218019	Chrysene	9.6E-06
PAH_176E5	86748	Carbazole	9.6E-06
PAH_192E3	8007452	Coal Tar	9.9E-04
PAH_880E5	130498292	PAH, total	4.8E-05

PAH Group	NEI Pollutant Code	NEI Pollutant Description	URE 1/(µg/m^3)
PAH_880E5	191242	Benzo[g,h,i,]Perylene	4.8E-05
PAH_880E5	192972	Benzo[e]Pyrene	4.8E-05
PAH_880E5	195197	Benzo(c)phenanthrene	4.8E-05
PAH_880E5	198550	Perylene	4.8E-05
PAH_880E5	203123	Benzo(g,h,i)Fluoranthene	4.8E-05
PAH_880E5	203338	Benzo(a)fluoranthene	4.8E-05
PAH_880E5	206440	Fluoranthene	4.8E-05
PAH_880E5	208968	Acenaphthylene	4.8E-05
PAH_880E5	2381217	1-Methylpyrene	4.8E-05
PAH_880E5	2422799	12-Methylbenz(a)Anthracene	4.8E-05
PAH_880E5	250	PAH/POM - Unspecified	4.8E-05
PAH_880E5	2531842	2-Methylphenanthrene	4.8E-05
PAH_880E5	26914181	Methylanthracene	4.8E-05
PAH_880E5	284	Extractable Organic Matter (EOM)	4.8E-05
PAH_880E5	56832736	Benzofluoranthenes	4.8E-05
PAH_880E5	65357699	Methylbenzopyrene	4.8E-05
PAH_880E5	779022	9-Methyl Anthracene	4.8E-05
PAH_880E5	832699	1-Methylphenanthrene	4.8E-05
PAH_880E5	83329	Acenaphthene	4.8E-05
PAH_880E5	86737	Fluorene	4.8E-05
PAH_880E5	90120	1-Methylnaphthalene	4.8E-05
PAH_880E5	91576	2-Methylnaphthalene	4.8E-05
PAH_880E5	91587	2-Chloronaphthalene	4.8E-05
PAH_880E5	N590	Polycyclic aromatic compounds (includes PAH/POM)	4.8E-05

The TOG and $PM_{2.5}$ speciation factors that are the basis of the chemical speciation approach were developed from a draft version of the SPECIATE 5.0 database (EPA, 2019; https://www.epa.gov/air-emissions-modeling/speciate), the EPA's repository of TOG and PM speciation profiles of air pollution sources. The SPECIATE database development and maintenance is a collaboration involving the EPA’s Office of Research and Development (ORD), Office of Transportation and Air Quality (OTAQ), and the Office of Air Quality Planning and Standards (OAQPS), in cooperation with Environment Canada (EPA, 2016). The SPECIATE database contains speciation profiles for TOG, speciated into individual chemical compounds, VOC-to-TOG conversion factors associated with the TOG profiles, and speciation profiles for $PM_{2.5}$.

As with previous platforms, some Canadian point source inventories are provided from Environment Canada as pre-speciated emissions; although not all CB6 species are provided, the inventories were not supplemented with missing species due to the minimal impact of supplementation.

Some key features and updates to speciation from previous platforms include the following (the subsections below contain more details on the specific changes):

- Use of the CBR3AE7 mechanism, as described earlier

- Several new VOC and $PM_{2.5}$ profiles added to SPECIATE 5.0 or slated for the next version of SPECIATE were used.
- $PM_{2.5}$ speciation process for nonroad mobile has been updated. Similar to VOC, $PM_{2.5}$ profiles are now assigned within MOVES2014b which outputs the emissions with those assignments.
- As with previous platforms, some Canadian point source inventories are provided from Environment Canada as pre-speciated emissions, and not all CB6 species were provided; missing species were supplemented by speciating total VOC.
- A new GSPRO_COMBO file was developed for use in Canada to account for ethanol mixes in Canadian gasoline.

Speciation profiles and cross-references for this study platform are available in the SMOKE input files for the platform. Totals of each model species by state and sector can be found in the state-sector totals workbook for this case.

For onroad mobile sources, speciation is done in MOVES, to allow for profiles that vary by model year, which is not part of the SCC code, to be used. Therefore, cross-references or emissions summaries by profile for onroad mobile sources are not provided. These profiles are documented in a MOVES technical report on speciation (EPA, 2018).

Updates to speciation profiles for VOC and PM2.5, were largely from the update of the SPECIATE database to version SPECIATE 5.0 in June 2019, which added numerous organic gas and PM profiles. We also used several profiles added to SPECIATE 5.1, which was released in the summer of 2020. In addition, we changed profile assignments to incorporate data provided by states or correct errors in previous assignments.

For PM2.5 the following profile updates were made for the 2017 platform:

- Corrected the wildfire and prescribed fire profile due to error in compositing (the previous profile included creosote in the average)
- Updated the profile for aircraft
- Corrected several profile assignments for the petroleum industry

For VOC the following profile updates were made for the 2017 platform:

- Consumer products - replaced the profiles developed from the CARB 1997 consumer products survey with profiles developed from the CARB 2010 survey update
- Oil and Gas – used additional region-specific profiles or updated assignments
  - Used county-specific profiles gas for several Wyoming counties developed from data provided by the Wyoming DEQ
  - Used Willison Basin gas composition data, separate profiles for the Montana and North Dakota portions of the basin, based on data developed by the Western Regional Air Partnership WRAP
  - Used Central Montana Uplift area gas composition data, based on data developed by the WRAP
  - Updated Uinta basin profile assignments (based on data provided by Utah)
  - Used Utah and Wyoming oil and gas produced water pond profiles

  - Updated profile assignments (by county and SCC) for nonpoint oil and gas sources that account for the portion of VOC estimated to come from flares. These were updated using results from the Oil and Gas estimation tool run that was used for the 2017 NEI
  - Updated profile assignment for miscellaneous engines to use internal combustion engine natural gas profile
- Commercial Marine vessel – changed profile assignment to an existing Pre-Tier 1 nonroad diesel profile because the previous profile was missing key species (aldehydes)
- Livestock – updated profile assignments
- Agricultural burning – updated profiles for rice straw and wheat straw burning, and used new sugar cane burning profile

3.2.1 VOC speciation

The speciation of VOC includes HAP emissions from the NEI in the speciation process. Instead of speciating VOC to generate all of the species listed in Table 3-3, emissions of five specific HAPs: naphthalene, benzene, acetaldehyde, formaldehyde and methanol (collectively known as "NBAFM") from the NEI were "integrated" with the NEI VOC. The integration combines these HAPs with the VOC in a way that does not double count emissions and uses the HAP inventory directly in the speciation process. The basic process is to subtract the specified HAPs emissions mass from the VOC emissions mass, and to then use a special "integrated" profile to speciate the remainder of VOC to the model species excluding the specific HAPs. The EPA believes that the HAP emissions in the NEI are often more representative of emissions than HAP emissions generated via VOC speciation, although this varies by sector.

The NBAFM HAPs were chosen for integration because they are the only explicit VOC HAPs in CMAQ version 5.2. Explicit means that they are not lumped chemical groups like PAR, IOLE and several other CB6 model species. These "explicit VOC HAPs" are model species that participate in the modeled chemistry using the CB6 chemical mechanism. The use of inventory HAP emissions along with VOC is called "HAP-CAP integration."

The integration of HAP VOC with VOC is a feature available in SMOKE for all inventory formats, including PTDAY (the format used for the ptfire and ptagfire sectors). The ability to use integration with the PTDAY format is used for the ptfire sector in the 2017 platform, but not for the ptagfire sector which does not include HAPs. SMOKE allows the user to specify the particular HAPs to integrate via the INVTABLE. This is done by setting the "VOC or TOG component" field to "V" for all HAP pollutants chosen for integration. SMOKE allows the user to also choose the specific sources to integrate via the NHAPEXCLUDE file (which actually provides the sources to be *excluded* from integration[17]). For the "integrated" sources, SMOKE subtracts the "integrated" HAPs from the VOC (at the source level) to compute emissions for the new pollutant "NONHAPVOC." The user provides NONHAPVOC-to-NONHAPTOG factors and NONHAPTOG speciation profiles.[18] SMOKE computes NONHAPTOG and then applies the speciation profiles to allocate the NONHAPTOG to the other air quality model VOC species not including the integrated HAPs. After determining if a sector is to be integrated, if all sources

[17] Since SMOKE version 3.7, the options to specify sources for integration are expanded so that a user can specify the particular sources to include or exclude from integration, and there are settings to include or exclude all sources within a sector. In addition, the error checking is significantly stricter for integrated sources. If a source is supposed to be integrated, but it is missing NBAFM or VOC, SMOKE will now raise an error.

[18] These ratios and profiles are typically generated from the Speciation Tool when it is run with integration of a specified list of pollutants, for example NBAFM.

have the appropriate HAP emissions, then the sector is considered fully integrated and does not need a NHAPEXCLUDE file. If, on the other hand, certain sources do not have the necessary HAPs, then an NHAPEXCLUDE file must be provided based on the evaluation of each source's pollutant mix. The EPA considered CAP-HAP integration for all sectors in determining whether sectors would have full, no or partial integration (see Figure 3-2). For sectors with partial integration, all sources are integrated other than those that have either the sum of NBAFM > VOC or the sum of NBAFM = 0.

For an air toxics platform such as this 2017 case, the "no-integrate" sources are treated differently from a criteria pollutant-focused (CAP) platform. For this 2017 case, the "no-integrate" approach removes the specified HAPs from the profile and still use the emissions of these HAPs from the NEI. It is very similar to the "integrate" case except that it does not renormalize the revised profile. In a CAP platform case, no-integrate means that no inventory HAPs are used. The explicit HAP model species are instead created by speciating the "no-integrate" source VOC emissions. In general, HAPs that are explicit in the chemical mechanism can be generated from either speciation or the inventory. We chose to use the HAPs in the inventory for this study since these are the data that are used to represent HAP emissions in the U.S. Also, HAP emissions in the NEI may be developed using more site-specific data (e.g., source testing, material balance) that would not be reflected by applying a speciation profile to VOC emissions. In addition, we have applied numerous HAP augmentation measures in the NEI. Since Canada and Mexico inventories do not contain HAPs, we use the approach of generating the HAPs via speciation, except for Mexico onroad mobile sources where emissions for integrate HAPs were available.

It should be noted that even though NBAFM were removed from the SPECIATE profiles used to create the GSPRO for both the NONHAPTOG and no-integrate TOG profiles, there still may be small fractions for "BENZ", "FORM", "ALD2", and "MEOH" present. This is because these model species may have come from species in SPECIATE that are mixtures. The quantity of these model species is expected to be very small compared to the BAFM in the NEI. There are no NONHAPTOG profiles that produce "NAPH."

In SMOKE, the INVTABLE allows the user to specify the specific HAPs to integrate. To support use of NBAFM emissions from the inventory for all sectors, regardless of integration status, all sectors used an INVTABLE in which the inventory NBAFM pollutants are kept and processed through SMOKE. NBAFM pollutants are labeled as integrate pollutants using the "VOC or TOG component" field, set to "V" for all five HAP pollutants. For the onroad and nonroad sectors, additional HAPs are labeled as integrate pollutants, in addition to NBAFM: 1,3 butadiene, acrolein, ethyl benzene, 2,2,4-Trimethylpentane, hexane, propionaldehyde, styrene, toluene, xylene, and methyl tert-butyl ether (MTBE). The integrated pollutants for this platform are shown in Table 3-7.

Figure 3-2. Process of integrating NBAFM with VOC for use in VOC Speciation

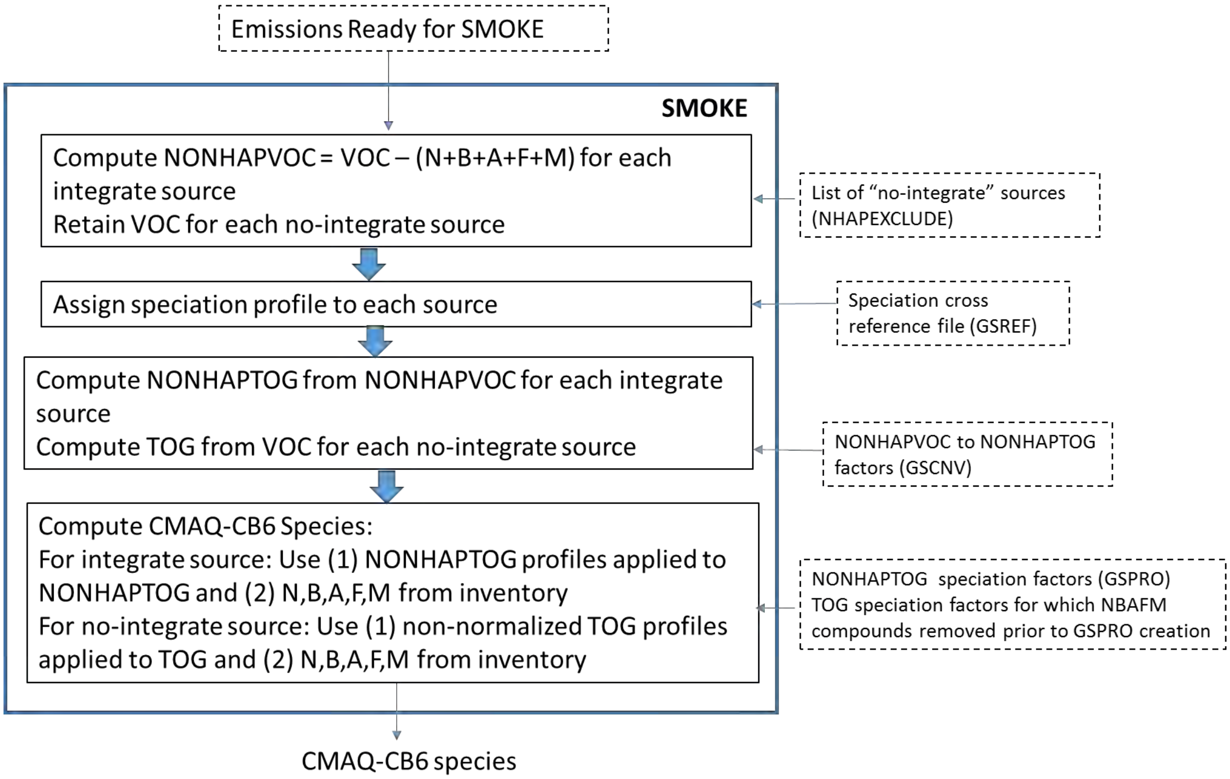


Table 3-7. Integration status of naphthalene, benzene, acetaldehyde, formaldehyde and methanol (NBAFM) for each platform sector

Platform Sector	Approach for Integrating NEI emissions of Naphthalene (N), Benzene (B), Acetaldehyde (A), Formaldehyde (F) and Methanol (M)
afdust	N/A – sector contains no VOC
ag	Partial integration (NBAFM), use NBAFM in inventory for no-integrate sources
airports	No integration, use NBAFM in inventory
beis	N/A – sector contains no inventory pollutant "VOC"; but rather specific VOC species
cmv_c1c2	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
cmv_c3	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
nonpt	Partial integration (NBAFM), use NBAFM in inventory for no-integrate sources
nonroad	Full integration (internal to MOVES)
np_oilgas	Partial integration (NBAFM), use NBAFM in inventory for no-integrate sources
onroad	Full integration (internal to MOVES)
onroad_can	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
onroad_mex	Full integration (internal to MOVES-Mexico); however, MOVES-MEXICO speciation was older CB6, so post-SMOKE emissions were converted to CB6R3AE7
othafdust	N/A – sector contains no VOC
othar	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
othpt	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
othptdust	N/A – sector contains no VOC

Platform Sector	Approach for Integrating NEI emissions of Naphthalene (N), Benzene (B), Acetaldehyde (A), Formaldehyde (F) and Methanol (M)
pt_oilgas	No integration, use NBAFM in inventory
ptagfire	Partial integration (NBAFM), use NBAFM in inventory for no-integrate sources
ptegu	No integration, use NBAFM in inventory
ptfire	Partial integration (NBAFM), use NBAFM in inventory for no-integrate sources
ptfire_othna	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
ptnonipm	No integration, use NBAFM in inventory
rail	Full integration (NBAFM)
rwc	Partial integration (NBAFM), use NBAFM in inventory for no-integrate sources

Integration for the mobile sources estimated from MOVES (onroad and nonroad sectors, other than for California) is done differently. Briefly there are three major differences: 1) for these sources integration is done using more than just NBAFM, 2) all sources from the MOVES model are integrated, and 3) integration is done fully or partially within MOVES. For onroad mobile, speciation is done fully within MOVES3 such that the MOVES model outputs emission factors for individual VOC model species along with the HAPs. This requires MOVES to be run for a specific chemical mechanism. For this platform MOVES was run for the CB6R3AE7 mechanism.

For nonroad mobile, speciation is partially done within MOVES such that it does not need to be run for a specific chemical mechanism. For nonroad, MOVES outputs emissions of HAPs and NONHAPTOG are split by speciation profile. Taking into account that integrated species were subtracted out by MOVES already, the appropriate speciation profiles are then applied in SMOKE to get the VOC model species. HAP integration for nonroad uses the same additional HAPs and ethanol as for onroad.

3.2.1.1 County specific profile combinations

SMOKE can compute speciation profiles from mixtures of other profiles in user-specified proportions via two different methods. The first method, which uses a GSPRO_COMBO file, has been in use since the 2005 platform; the second method (GSPRO with fraction) was used for the first time in the 2014v7.0 platform. The GSPRO_COMBO method uses profile combinations specified in the GSPRO_COMBO ancillary file by pollutant (which can include emissions mode, e.g., EXH__VOC), state and county (i.e., state/county FIPS code) and time period (i.e., month). Different GSPRO_COMBO files can be used by sector, allowing for different combinations to be used for different sectors; but within a sector, different profiles cannot be applied based on SCC. The GSREF file indicates that a specific source uses a combination file with the profile code "COMBO." SMOKE computes the resultant profile using the fraction of each specific profile assigned by county, month and pollutant.

In previous platforms, the GSPRO_COMBO feature was used to speciate nonroad mobile and gasoline-related stationary sources that use fuels with varying ethanol content. In these cases, the speciation profiles require different combinations of gasoline profiles, e.g. E0 and E10 profiles. Since the ethanol content varies spatially (e.g., by state or county), temporally (e.g., by month), and by modeling year (future years have more ethanol), the GSPRO_COMBO feature allows combinations to be specified at various levels for different years. For the 2017 platform, GSPRO_COMBO is still used for certain gasoline-related stationary sources nationwide. GSPRO_COMBO is no longer needed for nonroad sources because nonroad emissions within MOVES have the speciation profiles built into the results, so there is no need to assign them via the GSREF or GSPRO_COMBO feature.

Starting with the 2016v7.2 beta and regional haze platform, a GSPRO_COMBO is used to specify a mix of E0 and E10 fuels in Canada. ECCC provided percentages of ethanol use by province, and these were converted into E0 and E10 splits. For example, Alberta has 4.91% ethanol in its fuel, so we applied a mix of 49.1% E10 profiles (4.91% times 10, since 10% ethanol would mean 100% E10), and 50.9% E0 fuel. Ethanol splits for all provinces in Canada are listed in Table 3-8. The Canadian onroad inventory includes four distinct FIPS codes in Ontario, allowing for application of different E0/E10 splits in Southern Ontario versus Northern Ontario. In Mexico, only E0 profiles are used.

Table 3-8. Ethanol percentages by volume by Canadian province

Province	Ethanol % by volume (E10 = 10%)
Alberta	4.91%
British Columbia	5.57%
Manitoba	9.12%
New Brunswick	4.75%
Newfoundland & Labrador	0.00%
Nova Scotia	0.00%
NW Territories	0.00%
Nunavut	0.00%
Ontario (Northern)	0.00%
Ontario (Southern)	7.93%
Prince Edward Island	0.00%
Québec	3.36%
Saskatchewan	7.73%
Yukon	0.00%

A new method to combine multiple profiles became available in SMOKE4.5. It allows multiple profiles to be combined by pollutant, state and county (i.e., state/county FIPS code) and SCC. This was used specifically for the oil and gas sectors (pt_oilgas and np_oilgas) because SCCs include both controlled and uncontrolled oil and gas operations which use different profiles.

3.2.1.2 Additional sector specific considerations for integrating HAP emissions from inventories into speciation

The decision to integrate HAPs into the speciation was made on a sector-by-sector basis. For some sectors, there is no integration and VOC is speciated directly; for some sectors, there is full integration meaning all sources are integrated; and for other sectors, there is partial integration, meaning some sources are not integrated and other sources are integrated. The integrated HAPs are either NBAFM or, in the case of MOVES (onroad, nonroad, and MOVES-Mexico), a larger set of HAPs plus ethanol are integrated. Table 3-6 above summarizes the integration method for each platform sector.

Speciation for the onroad sector is unique. First, SMOKE-MOVES is used to create emissions for these sectors and both the MEPROC and INVTABLE files are involved in controlling which pollutants are processed. Second, the speciation occurs within MOVES itself, not within SMOKE. The advantage of using MOVES to speciate VOC is that during the internal calculation of MOVES, the model has complete information on the characteristics of the fleet and fuels (e.g., model year, ethanol content, process, etc.), thereby allowing it to more accurately make use of specific speciation profiles. This means that MOVES produces emission factor tables that include inventory pollutants (e.g., TOG) and model-ready species (e.g., PAR, OLE, etc).[19] SMOKE essentially calculates the model-ready species by using the appropriate emission factor without further speciation.[20] Third, MOVES' internal speciation uses full integration of an extended list of HAPs beyond NBAFM (called "M-profiles"). The M-profiles integration is very similar to NBAFM integration explained above except that the integration calculation (see Figure 3-2) is performed on emissions factors instead of on emissions, and a much larger set of pollutants are integrated besides NBAFM. The list of integrated pollutants is described in Table 3-9. An additional run of the Speciation Tool was necessary to create the M-profiles that were then loaded into the MOVES default database. Fourth, for California, the EPA applied adjustment factors to SMOKE-MOVES to produce California adjusted model-ready files. By applying the ratios through SMOKE-MOVES, the CARB inventories are essentially speciated to match EPA estimated speciation. This resulted in changes to the VOC HAPs from what CARB submitted to the EPA.

Table 3-9. MOVES integrated species in M-profiles

MOVES ID	Pollutant Name
5	Methane (CH4)
20	Benzene
21	Ethanol
22	MTBE
24	1,3-Butadiene
25	Formaldehyde
26	Acetaldehyde
27	Acrolein
40	2,2,4-Trimethylpentane
41	Ethyl Benzene
42	Hexane
43	Propionaldehyde
44	Styrene
45	Toluene
46	Xylene
185	Naphthalene gas

For the nonroad sector, all sources are integrated using the same list of integrated pollutants as shown in Table 3-9. The integration calculations are performed within MOVES. For California and Texas, all VOC HAPs were recalculated using MOVES HAP/VOC ratios based on the MOVES run so that VOC speciation methodology would be consistent across the country. NONHAPTOG emissions by speciation profile were also calculated based on MOVES data in California in Texas.

For nonroad emissions in California where the state provided emissions, MOVES-style speciation has been implemented in 2017, with NONHAPTOG and PM2.5 pre-split by profiles and with all the HAPs

[19] Because the EF table has the speciation "baked" into the factors, all counties that are in the county group (i.e., are mapped to that representative county) will have the same speciation.
[20] For more details on the use of model-ready EF, see the SMOKE 3.7 documentation: https://www.cmascenter.org/smoke/documentation/3.7/html/.

needed for VOC speciation augmented based on MOVES data in California. This means in 2017, nonroad emissions in California are speciated consistently with the rest of the country.

MOVES-MEXICO for onroad used the same speciation approach as for the U.S. in that the larger list of species shown in Table 3-8 was used. However, MOVES-MEXICO used an older version of the CB6 mechanism sometimes referred to as "CB6-CAMx". That mechanism is missing the XYLMN and SOAALK species in particular, so post-SMOKE we converted the emissions to CB6-CMAQ as follows:

- XYLMN = XYL[1]-0.966*NAPHTHALENE[1]
- PAR = PAR[1]-0.00001*NAPHTHALENE[1]
- SOAALK = 0.108*PAR[1]

The CB6R3AE7 mechanism includes other new species which are not part of CB6-CAMx, such as IVOC. CB6R3AE7-specific species were not added to the MOVES-MEXICO emissions because those extra species would be expected to have only a minor impact.

For the beis sector, the speciation profiles used by BEIS are not included in SPECIATE. BEIS3.7 includes the species (SESQ) that is mapped to the BEIS model species SESQT (Sesquiterpenes). The profile code associated with BEIS3.7 for use with CB6R3AE7 is "BC6E7". The difference in the biogenic profile compared to the previous version of CB6, based on profile code "B10C6", is the explicit treatment of acetic acid, formic acid, and alpha-pinine emissions in BC6E7. The biogenic speciation files are managed in the CMAQ Github repository.[21]

3.2.1.3 Oil and gas related speciation profiles

Several oil and gas profiles were developed or assigned to sources in np_oilgas and pt_oilgas to better reflect region-specific differences in VOC composition and whether the process SCC would include controlled emissions, considering the controls are not part of the SCC. The basin / region-specific profiles for oil and gas are shown in Table 3-10.

In addition to region-specific assignments, multiple profiles were assigned to particular county/SCC combinations using the SMOKE feature discussed in 3.2.1.1 that allows multiple profiles to be combined within the chemical speciation cross reference file (GSREF) by pollutant, state/county, and SCC. Oil and gas SCCs for associated gas, condensate tanks, crude oil tanks, dehydrators, liquids unloading and well completions represent the total VOC from the process, including the portions of process that may be flared or directed to a reboiler. For example, SCC 2310021400 (gas well dehydrators) consists of process, reboiler, and/or flaring emissions. There are not separate SCCs for the flared portion of the process or the reboiler. However, the VOC associated with these three portions can have very different speciation profiles. Therefore, it is necessary to have an estimate of the amount of VOC from each of the portions (process, flare, reboiler) so that the appropriate speciation profiles can be applied to each portion. The Nonpoint Oil and Gas Emission Estimation Tool generates an intermediate file which provides flare, non-flare (process), and reboiler (for dehydrators) emissions for six source categories that have flare emissions: by county FIPS and SCC code for the U.S. From these emissions the fraction of the emissions to assign to each profile was computed and incorporated into the 2017 platform. These fractions can vary by county FIPS, because they depend on the level of controls, which is an input to the Speciation Tool.

Table 3-10. Basin/Region-specific profiles for oil and gas

Profile Code	Description	Region (if not in profile name)
DJVNT_R	Denver-Julesburg Basin Produced Gas Composition from Non-CBM Gas Wells	
PNC01_R	Piceance Basin Produced Gas Composition from Non-CBM Gas Wells	
PNC02_R	Piceance Basin Produced Gas Composition from Oil Wells	
PRBCB_R	Powder River Basin Produced Gas Composition from CBM Wells	
PRBCO_R	Powder River Basin Produced Gas Composition from Non-CBM Wells	
PRM01_R	Permian Basin Produced Gas Composition for Non-CBM Wells	
SSJCB_R	South San Juan Basin Produced Gas Composition from CBM Wells	
SSJCO_R	South San Juan Basin Produced Gas Composition from Non-CBM Gas Wells	
SWFLA_R	SW Wyoming Basin Flash Gas Composition for Condensate Tanks	
SWVNT_R	SW Wyoming Basin Produced Gas Composition from Non-CBM Wells	
UNT01_R	Uinta Basin Produced Gas Composition from CBM Wells	
WRBCO_R	Wind River Basin Produced Gagres Composition from Non-CBM Gas Wells	
95087a	Oil and Gas - Composite - Oil Field - Oil Tank Battery Vent Gas	East Texas
95109a	Oil and Gas - Composite - Oil Field - Condensate Tank Battery Vent Gas	East Texas
95417	Uinta Basin, Untreated Natural Gas	
95418	Uinta Basin, Condensate Tank Natural Gas	
95419	Uinta Basin, Oil Tank Natural Gas	
95420	Uinta Basin, Glycol Dehydrator	
95398	Composite Profile - Oil and Natural Gas Production - Condensate Tanks	Denver-Julesburg
95399	Composite Profile - Oil Field – Wells	California
95400	Composite Profile - Oil Field – Tanks	California
95403	Composite Profile - Gas Wells	San Joaquin
CMU01	Oil and Gas - Produced Gas Composition from Gas Wells - Central Montana Uplift – Montana	
WIL01	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin North Dakota	
WIL02	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin Montana	
WIL03	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin North Dakota	
WIL04	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin Montana	

3.2.1.4 Mobile source related VOC speciation profiles

The VOC speciation approach for mobile source and mobile source-related source categories is customized to account for the impact of fuels and engine type and technologies. The impact of fuels also affects the parts of the nonpt and ptnonipm sectors that are related to mobile sources such as portable fuel containers and gasoline distribution.

The VOC speciation profiles for the nonroad sector other than for California are listed in Table 3-11. They include new profiles (i.e., those that begin with "953") for 2-stroke and 4-stroke gasoline engines running on E0 and E10 and compression ignition engines with different technologies developed from recent EPA test programs, which also supported the updated toxics emission factor in MOVES2014a (Reichle, 2015 and EPA, 2015b).

Table 3-11. TOG MOVES-SMOKE Speciation for nonroad emissions used for the 2017 Platform

Profile	Profile Description	Engine Type	Engine Technology	Engine Size	Horse-power category	Fuel	Fuel Sub-type	Emission Process
95328	SI 2-stroke E10	SI 2-stroke	All	All	All	Gasoline	E10	exhaust
95330	SI 4-stroke E10	SI 4-stroke	All	All	All	Gasoline	E10	exhaust
95331	CI Pre-Tier 1	CI	Pre-Tier 1	All	All	Diesel	All	exhaust
95332	CI Tier 1	CI	Tier 1	All	All	Diesel	All	exhaust
95333	CI Tier 2	CI	Tier 2 and 3	all	All	Diesel	All	exhaust
95335a [21]	CI Tier 2	CI	Tier 4	<56 kW (75 hp)	S	Diesel	All	exhaust
8775	ACES Phase 1 Diesel Onroad	CI Tier 4	Tier 4	>=56 kW (75 hp)	L	Diesel	All	exhaust
8754	E10 Evap	SI	All	all	All	Gasoline	E10	evaporative
8769	E10 evap permeation	SI	All	all	All	Gasoline	E10	permeation
8870	E10 Headspace	SI	All	all	All	Gasoline	E10	headspace
1001	CNG Exhaust	All	all	all	All	CNG	All	exhaust
8860	LPG exhaust	All	all	all	All	LPG	All	exhaust

Speciation profiles for VOC in the nonroad sector account for the ethanol content of fuels across years. A description of the actual fuel formulations can be found in NEITSD. For previous platforms, the EPA used "COMBO" profiles to model combinations of profiles for E0 and E10 fuel use, but beginning with 2014v7.0 platform, the appropriate allocation of E0 and E10 fuels is done by MOVES.

Combination profiles reflecting a combination of E10 and E0 fuel use ideally would be used for sources upstream of mobile sources such as portable fuel containers (PFCs) and other fuel distribution operations associated with the transfer of fuel from bulk terminals to pumps (BTP), which are in the nonpt sector. For these sources, ethanol may be mixed into the fuels, in which case speciation would change across years. The speciation changes from fuels in the ptnonipm sector include BTP distribution operations inventoried as point sources. Refinery-to-bulk terminal (RBT) fuel distribution and bulk plant storage (BPS) speciation does not change across the modeling cases because this is considered upstream from the introduction of ethanol into the fuel. The mapping of fuel distribution SCCs to PFC, BTP, BPS, and RBT emissions categories can be found in Appendix C. In 2017 platform, all of these sources get E10 speciation.

[21] 95335a replaced 95335. This correction was made to remove alcohols due to suspected contamination. Additional information is available in SPECIATE.

Table 3-12 summarizes the different profiles utilized for the fuel-related sources in each of the sectors. The term "COMBO" indicates that a combination of the profiles listed was used to speciate that subcategory using the GSPRO_COMBO file.

Table 3-12. Select mobile-related VOC profiles 2017

Sector	Sub-category	Profile	
Nonroad non-US	gasoline exhaust	COMBO 8750a 8751a	 Pre-Tier 2 E0 exhaust Pre-Tier 2 E10 exhaust
nonpt/ ptnonipm	PFC and BTP	8870	E10 Headspace
nonpt/ ptnonipm	Bulk plant storage (BPS) and refine-to-bulk terminal (RBT) sources	8870	E10 Headspace

The speciation of onroad VOC occurs completely within MOVES. MOVES accounts for fuel type and properties, emission standards as they affect different vehicle types and model years, and specific emission processes. Table 3-13 describes the M-profiles available to MOVES depending on the model year range, MOVES process (processID), fuel sub-type (fuelSubTypeID), and regulatory class (regClassID). m While MOVES maps the liquid diesel profile to several processes, MOVES only estimates emissions from refueling spillage loss (processID 19). The other evaporative and refueling processes from diesel vehicles have zero emissions.

Table 3-14 through Table 3-16 describe the meaning of these MOVES codes. For a specific representative county and future year, there will be a different mix of these profiles. For example, for HD diesel exhaust, the emissions will use a combination of profiles 8774M and 8775M depending on the proportion of HD vehicles that are pre-2007 model years (MY) in that particular county. As that county is projected farther into the future, the proportion of pre-2007 MY vehicles will decrease. A second example, for gasoline exhaust (not including E-85), the emissions will use a combination of profiles 8756M, 8757M, 8758M, 8750aM, and 8751aM. Each representative county has a different mix of these key properties and, therefore, has a unique combination of the specific M-profiles. More detailed information on how MOVES speciates VOC and the profiles used is provided in the technical document, "Speciation of Total Organic Gas and Particulate Matter Emissions from On-road Vehicles in MOVES2014" (EPA, 2015c).

Table 3-13. Onroad M-profiles

Profile	Profile Description	Model Years	ProcessID	FuelSubTypeID	RegClassID
1001M	CNG Exhaust	1940-2050	1,2,15,16	30	48
4547M	Diesel Headspace	1940-2050	11	20,21,22	0
4547M	Diesel Headspace	1940-2050	12,13,18,19	20,21,22	10,20,30,40,41, 42,46,47,48
8753M	E0 Evap	1940-2050	12,13,19	10	10,20,30,40,41,42, 46,47,48
8754M	E10 Evap	1940-2050	12,13,19	12,13,14	10,20,30,40,41, 42,46,47,48

Profile	Profile Description	Model Years	ProcessID	FuelSubTypeID	RegClassID
8756M	Tier 2 E0 Exhaust	2001-2050	1,2,15,16	10	20,30
8757M	Tier 2 E10 Exhaust	2001-2050	1,2,15,16	12,13,14	20,30
8758M	Tier 2 E15 Exhaust	1940-2050	1,2,15,16	15,18	10,20,30,40,41, 42,46,47,48
8766M	E0 evap permeation	1940-2050	11	10	0
8769M	E10 evap permeation	1940-2050	11	12,13,14	0
8770M	E15 evap permeation	1940-2050	11	15,18	0
8774M	Pre-2007 MY HDD exhaust	1940-2006	1,2,15,16,17,90	20, 21, 22	40,41,42,46,47, 48
8774M	Pre-2007 MY HDD exhaust	1940-2050	91[22]	20, 21, 22	46,47
8774M	Pre-2007 MY HDD exhaust	1940-2006	1,2,15,16	20, 21, 22	20,30
8775M	2007+ MY HDD exhaust	2007-2050	1,2,15,16	20, 21, 22	20,30
8775M	2007+ MY HDD exhaust	2007-2050	1,2,15,16,17,90	20, 21, 22	40,41,42,46,47,48
8855M	Tier 2 E85 Exhaust	1940-2050	1,2,15,16	50, 51, 52	10,20,30,40,41, 42,46,47,48
8869M	E0 Headspace	1940-2050	18	10	10,20,30,40,41, 42,46,47,48
8870M	E10 Headspace	1940-2050	18	12,13,14	10,20,30,40,41, 42,46,47,48
8871M	E15 Headspace	1940-2050	18	15,18	10,20,30,40,41, 42,46,47,48
8872M	E15 Evap	1940-2050	12,13,19	15,18	10,20,30,40,41, 42,46,47,48
8934M	E85 Evap	1940-2050	11	50,51,52	0
8934M	E85 Evap	1940-2050	12,13,18,19	50,51,52	10,20,30,40,41, 42,46,47,48
8750aM	Pre-Tier 2 E0 exhaust	1940-2000	1,2,15,16	10	20,30
8750aM	Pre-Tier 2 E0 exhaust	1940-2050	1,2,15,16	10	10,40,41,42,46,47,48
8751aM	Pre-Tier 2 E10 exhaust	1940-2000	1,2,15,16	11,12,13,14	20,30
8751aM	Pre-Tier 2 E10 exhaust	1940-2050	1,2,15,16	11,12,13,14,15, 18[23]	10,40,41,42,46,47,48
95120[m]	Liquid Diesel	19602060	11	20,21,22	0
95120[m]	Liquid Diesel	19602060	12,13,18,19	20,21,22	10,20,30,40,41,42,46,47,4 8
95335a	2010+ MY HDD exhaust	20102060	1,2,15,16,17,90	20,21,22	40,41,42,46,47,48

[m] While MOVES maps the liquid diesel profile to several processes, MOVES only estimates emissions from refueling spillage loss (processID 19). The other evaporative and refueling processes from diesel vehicles have zero emissions.

[22] 91 is the processed for APUs which are diesel engines not covered by the 2007 Heavy-Duty Rule, so the older technology applies to all years.

[23] The profile assignments for pre-2001 gasoline vehicles fueled on E15/E20 fuels (subtypes 15 and 18) were corrected for MOVES2014a. This model year range, process, fuelsubtype regclass combinate is already assigned to profile 8758.

Table 3-14. MOVES process IDs

Process ID	Process Name
1	Running Exhaust
2	Start Exhaust
9	Brakewear
10	Tirewear
11	Evap Permeation
12	Evap Fuel Vapor Venting
13	Evap Fuel Leaks
15	Crankcase Running Exhaust
16	Crankcase Start Exhaust
17	Crankcase Extended Idle Exhaust
18	Refueling Displacement Vapor Loss
19	Refueling Spillage Loss
20	Evap Tank Permeation
21	Evap Hose Permeation
22	Evap RecMar Neck Hose Permeation
23	Evap RecMar Supply/Ret Hose Permeation
24	Evap RecMar Vent Hose Permeation
30	Diurnal Fuel Vapor Venting
31	HotSoak Fuel Vapor Venting
32	RunningLoss Fuel Vapor Venting
40	Nonroad
90	Extended Idle Exhaust
91	Auxiliary Power Exhaust

Table 3-15. MOVES Fuel subtype IDs

Fuel Subtype ID	Fuel Subtype Descriptions
10	Conventional Gasoline
11	Reformulated Gasoline (RFG)
12	Gasohol (E10)
13	Gasohol (E8)
14	Gasohol (E5)
15	Gasohol (E15)
18	Ethanol (E20)
20	Conventional Diesel Fuel
21	Biodiesel (BD20)
22	Fischer-Tropsch Diesel (FTD100)
30	Compressed Natural Gas (CNG)
50	Ethanol
51	Ethanol (E85)
52	Ethanol (E70)

Table 3-16. MOVES regclass IDs

Reg. Class ID	Regulatory Class Description
0	Doesn't Matter
10	Motorcycles
20	Light Duty Vehicles
30	Light Duty Trucks
40	Class 2b Trucks with 2 Axles and 4 Tires (8,500 lbs < GVWR <= 10,000 lbs)
41	Class 2b Trucks with 2 Axles and at least 6 Tires or Class 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs)
42	Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs)
46	Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs)
47	Class 8a and 8b Trucks (GVWR > 33,000 lbs)
48	Urban Bus (see CFR Sec 86.091_2)

For portable fuel containers (PFCs) and fuel distribution operations associated with the bulk-plant-to-pump (BTP) distribution, a 10% ethanol mix (E10) was assumed for speciation purposes. Refinery to bulk terminal (RBT) fuel distribution and bulk plant storage (BPS) speciation are considered upstream from the introduction of ethanol into the fuel; therefore, a single profile is sufficient for these sources. No refined information on potential VOC speciation differences between cellulosic diesel and cellulosic ethanol sources was available; therefore, cellulosic diesel and cellulosic ethanol sources used the same SCC (30125010: Industrial Chemical Manufacturing, Ethanol by Fermentation production) for VOC speciation as was used for corn ethanol plants.

3.2.2 PM speciation

In addition to VOC profiles, the SPECIATE database also contains profiles for speciating $PM_{2.5}$. $PM_{2.5}$ was speciated into the AE6 species associated with CMAQ 5.0.1 and later versions. Of particular note for this platform, the nonroad $PM_{2.5}$ speciation was updated as discussed later in this section. Most of the PM profiles come from the 911XX series (Reff et. al, 2009), which include updated AE6 speciation.[24] Starting with the 2014v7.1 platform, profile 91112 (Natural Gas Combustion – Composite) was replaced with 95475 (Composite -Refinery Fuel Gas and Natural Gas Combustion). This updated profile is an AE6-ready profile based on the median of 3 SPECIATE4.5 profiles from which AE6 versions were made (to be added to SPECIATE5.0): boilers (95125a), process heaters (95126a) and internal combustion combined cycle/cogen plant exhaust (95127a). As with profile 91112, these profiles are based on tests using natural gas and refinery fuel gas (England et al., 2007). Profile 91112 which is also based on refinery gas and natural gas is thought to overestimate EC.

Profile 95475 (Composite -Refinery Fuel Gas and Natural Gas Combustion) is shown along with the underlying profiles composited in Figure 3-3. Figure 3-4 shows a comparison of the new profile as of the 2014v7.1 platform with the one that we had been using in the 2014v7.0 and earlier platforms.

[24] The exceptions are 5675AE6 (Marine Vessel – Marine Engine – Heavy Fuel Oil) used for cmv_c3 and 92018 (Draft Cigarette Smoke – Simplified) used in nonpt. 5675AE6 is an update of profile 5675 to support AE6 PM speciation.

Figure 3-3. Profiles composited for PM gas combustion related sources

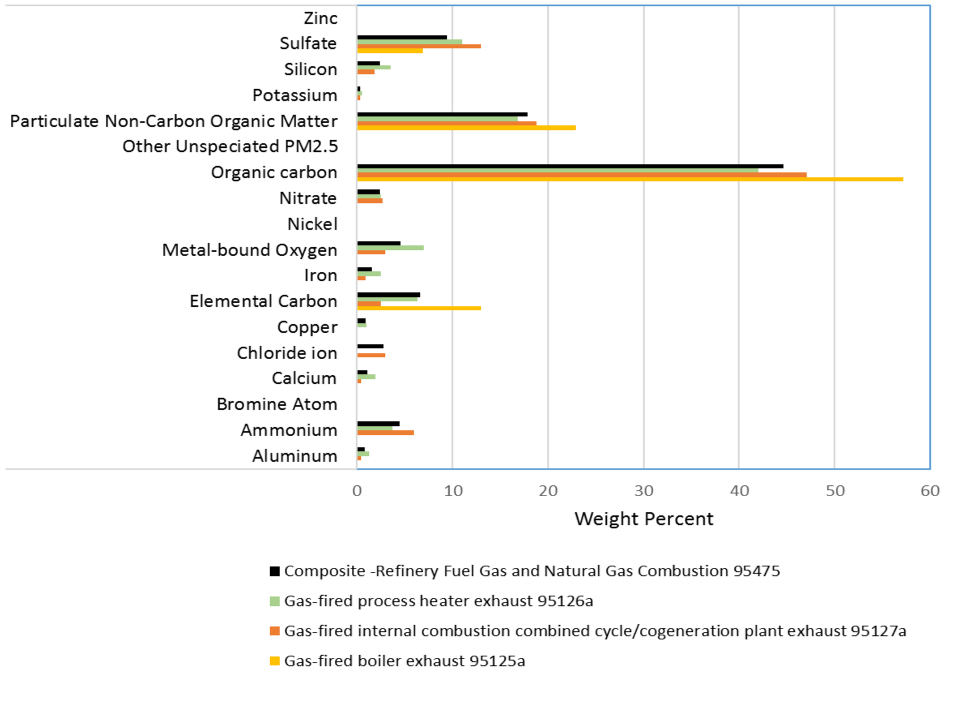
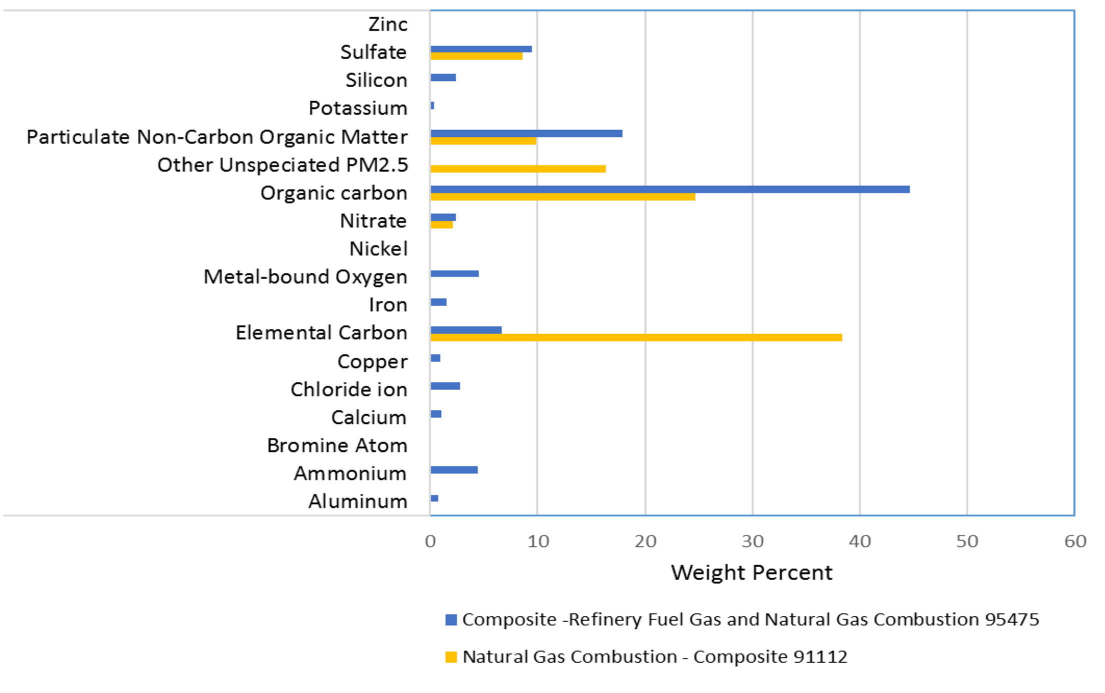


Figure 3-4. Comparison of PM profiles used for Natural gas combustion related sources



3.2.2.1 Mobile source related PM2.5 speciation profiles

For all processes except brake and tire wear in the onroad sector, PM speciation occurs within MOVES itself, not within SMOKE (similar to the VOC speciation described above). The advantage of using MOVES to speciate PM is that during the internal calculation of MOVES, the model has complete information on the characteristics of the fleet and fuels (e.g., model year, sulfur content, process, etc.) to accurately match to specific profiles. This means that MOVES produces EF tables that include total PM (e.g., PM_{10} and $PM_{2.5}$) and speciated PM (e.g., PEC, PFE). SMOKE essentially calculates the PM components by using the appropriate EF without further speciation.[25] The specific profiles used within MOVES include two CNG profiles, 45219 and 45220, which were added to SPECIATE4.5. A list of profiles is provided in the technical document, "Speciation of Total Organic Gas and Particulate Matter Emissions from On-road Vehicles in MOVES2014" (EPA, 2015c).

For onroad brake and tire wear, the PM is speciated in the *moves2smk* postprocessor that prepares the emission factors for processing in SMOKE. The formulas for this are based on the standard speciation factors from brake and tire wear profiles, which were updated from the v6.3 platform based on data from a Health Effects Institute report (Schauer, 2006). Table 3-17 shows the differences in the v7.1 (alpha) and 2011v6.3 profiles.

Table 3-17. Brake and tire PM2.5 profiles from Schauer (2006)

Inventory Pollutant	Model Species	SPECIATE4.5 brakewear profile: 95462	SPECIATE4.5 tirewear profile: 95460
PM2_5	PAL	0.000793208	3.32401E-05
PM2_5	PCA	0.001692177	
PM2_5	PCL		
PM2_5	PEC	0.012797085	0.003585907
PM2_5	PFE	0.213901692	0.00024779
PM2_5	PH2O		
PM2_5	PK	0.000687447	4.33129E-05
PM2_5	PMG	0.002961309	0.000018131
PM2_5	PMN	0.001373836	1.41E-06
PM2_5	PMOTHR	0.691704999	0.100663209
PM2_5	PNA	0.002749787	7.35312E-05
PM2_5	PNCOM	0.020115749	0.255808124
PM2_5	PNH4		
PM2_5	PNO3		
PM2_5	POC	0.050289372	0.639520309
PM2_5	PSI		
PM2_5	PSO4		
PM2_5	PTI	0.000933341	5.04E-06

For California onroad emissions, adjustment factors were applied to SMOKE-MOVES to produce California adjusted model-ready files. California did not supply speciated PM, therefore, the adjustment

[25] Unlike previous platforms, the PM components (e.g., POC) are now consistently defined between MOVES2014 and CMAQ. For more details on the use of model-ready EF, see the SMOKE 3.7 documentation: https://www.cmascenter.org/smoke/documentation/3.7/html/.

factors applied to PM2.5 were also applied to the speciated PM components. By applying the ratios through SMOKE-MOVES, the CARB inventories are essentially speciated to match EPA estimated speciation.

For nonroad PM2.5, speciation is partially done within MOVES such that it does not need to be run for a specific chemical mechanism. For nonroad, MOVES outputs emissions of PM2.5 split by speciation profile. Similar to how VOC and NONHAPTOG are speciated, PM2.5 is now also speciated this way starting with MOVES2014b. For California, PM2.5 emissions split by speciation profile are estimated from total PM2.5 based on MOVES data in California, so that PM is speciated consistently across the country. The PM2.5 profiles assigned to nonroad sources are listed in Table 3-18.

Table 3-18. Nonroad PM2.5 profiles

SPECIATE4.5 Profile Code	SPECIATE4.5 Profile Name	Assigned to Nonroad sources based on Fuel Type
8996	Diesel Exhaust - Heavy-heavy duty truck - 2007 model year with NCOM	Diesel
91106	HDDV Exhaust – Composite	Diesel
91113	Nonroad Gasoline Exhaust – Composite	Gasoline
95219	CNG Transit Bus Exhaust	CNG and LPG

3.2.2.2 Diesel PM

Diesel particulate matter is neither a CAP nor HAP as defined by Section 112 of the CAA, however it was identified as a mobile source air toxic in EPA's 2007 rule, "Control of Hazardous Air Pollutants From Mobile Sources final rule" (EPA 2007a). Starting with the 2014 NEI, diesel PM emissions are explicitly included in the NEI using pollutant names DIESEL-PM10 and DIESEL-PM25, respectively. Diesel PM emissions are tracked for mobile-source, engine-exhaust PM_{10} and $PM_{2.5}$ emissions from engines burning diesel or residual-oil fuels. These sources include on-road, nonroad, point-airport-ground support equipment, point-locomotives, nonpoint locomotives, and all PM from diesel or residual-oil-fueled nonpoint CMVs. For these sources, DIESEL-PM10 and DIESEL-PM25 are equal to primary PM10-PRI and PM25-PRI in the NEI. Although stationary engines also can burn diesel fuel, only mobile-related diesel engine SCCs have diesel PM emissions modeled.

Diesel PM is speciated in SMOKE using the same speciation profiles as primary PM, except that diesel PM is mapped to the following model species: DIESEL_PMC (PMC), DIESEL_PMEC (PEC), DIESEL_PMOC (POC), DIESEL_PMNO3 (PNO3), DIESEL_PMSO4 (PSO4), and DIESEL_PMFINE (all other $PM_{2.5}$ species).

3.2.3 NO_X speciation

NOx emission factors and therefore NOx inventories are developed on a NO_2 weight basis. For air quality modeling, NO_X is speciated into NO, NO_2, and/or HONO. For the non-mobile sources, the EPA used a single profile "NHONO" to split NO_X into NO and NO_2.

The importance of HONO chemistry, identification of its presence in ambient air and the measurements of HONO from mobile sources have prompted the inclusion of HONO in NOx speciation for mobile sources. Based on tunnel studies, a HONO to NOx ratio of 0.008 was chosen (Sarwar, 2008). For the mobile sources, except for onroad (including nonroad, cmv, rail, othon sectors), and for specific SCCs in othar and ptnonipm, the profile "HONO" is used. Table 3-19 gives the split factor for these two profiles. The onroad sector does not use the "HONO" profile to speciate NO_X. MOVES2014 produces speciated NO, NO_2, and HONO by source, including emission factors for these species in the emission factor tables used by SMOKE-MOVES. Within MOVES, the HONO fraction is a constant 0.008 of NO_X. The NO fraction varies by heavy duty versus light duty, fuel type, and model year. The NO_2 fraction is calculated as the remainder (i.e., NO_2 1 – NO – HONO). For more details on the NO_X fractions within MOVES, see EPA report "Use of data from 'Development of Emission Rates for the MOVES Model,' Sierra Research, March 3, 2010" available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100F1A5.pdf.

Table 3-19. NO_X speciation profiles

Profile	Pollutant	species	Molar split factor
HONO	NOX	NO2	0.092
HONO	NOX	NO	0.9
HONO	NOX	HONO	0.008
NHONO	NOX	NO2	0.1
NHONO	NOX	NO	0.9

3.2.4 Creation of Sulfuric Acid Vapor (SULF)

Since at least the 2002 Platform, sulfuric acid vapor (SULF) has been estimated through the SMOKE speciation process for coal combustion and residual and distillate oil fuel combustion sources. Profiles that compute SULF from SO_2 are assigned to coal and oil combustion SCCs in the GSREF ancillary file. The profiles were derived from information from AP-42 (EPA, 1998), which identifies the fractions of sulfur emitted as sulfate and SO_2 and relates the sulfate as a function of SO2.

Sulfate is computed from SO_2 emissions assuming that gaseous sulfate, which is comprised of many components, is primarily H_2SO_4. The equation for calculating H_2SO_4 is given below.

$$Emissions\ of\ SULF\ (as\ \mathrm{H_2SO_4}) = SO_2\ emissions \times \frac{fraction\ of\ S\ emitted\ as\ sulfate}{fraction\ of\ S\ emitted\ as\ SO_2} \times \frac{MW\ H_2SO_4}{MW\ SO_2}$$ Equation 3-1

In the above, *MW* is the molecular weight of the compound. The molecular weights of H_2SO_4 and SO_2 are 98 g/mol and 64 g/mol, respectively.

This method does not reduce SO_2 emissions; it solely adds gaseous sulfate emissions as a function of SO2 emissions. The derivation of the profiles is provided in Table 3-20; a summary of the profiles is provided in Table 3-21.

Table 3-20. Sulfate split factor computation

fuel	SCCs	Profile Code	Fraction as SO2	Fraction as Sulfate	Split factor (mass fraction)

Bituminous	1-0X-002-YY, where X is 1, 2 or 3 and YY is 01 thru 19 and 21-ZZ-002-000 where ZZ is 02,03 or 04	95014	0.95	0.014	.014/.95 * 98/64 = 0.0226
Subbituminous	1-0X-002-YY, where X is 1, 2 or 3 and YY is 21 thru 38	87514	.875	0.014	.014/.875 * 98/64 = 0.0245
Lignite	1-0X-003-YY, where X is 1, 2 or 3 and YY is 01 thru 18 and 21-ZZ-002-000 where ZZ is 02,03 or 04	75014	0.75	0.014	.014/.75 * 98/64 = 0.0286
Residual oil	1-0X-004-YY, where X is 1, 2 or 3 and YY is 01 thru 06 and 21-ZZ-005-000 where ZZ is 02,03 or 04	99010	0.99	0.01	.01/.99 * 98/64 = 0.0155
Distillate oil	1-0X-005-YY, where X is 1, 2 or 3 and YY is 01 thru 06 and 21-ZZ-004-000 where ZZ is 02,03 or 04	99010	0.99	0.01	Same as residual oil

Table 3-21. SO_2 speciation profiles

Profile	pollutant	species	split factor
95014	SO2	SULF	0.0226
95014	SO2	SO2	1
87514	SO2	SULF	0.0245
87514	SO2	SO2	1
75014	SO2	SULF	0.0286
75014	SO2	SO2	1
99010	SO2	SULF	0.0155
99010	SO2	SO2	1

3.2.5 Speciation of Metals and Mercury

Mercury and other metals from the inventory were speciated for use in modeling. Other than the facility specific data for one facility provided by Minnesota, the profiles are the same as were used in previous modeling platforms and are documented in Appendix D of the Technical Support Document for the 2011 National-scale Air Toxics Assessment (https://www.epa.gov/sites/production/files/2015-12/documents/2011-nata-tsd.pdf). Mercury in the inventory was reported as pollutant code 7439976 and needs to be speciated into the three forms of mercury used by CMAQ: elemental, divalent gaseous, and divalent particulate. Metals (other than mercury) were speciated into coarse and fine particulate, which are needed by CMAQ. Table 3-22 contains summaries of the particle size profiles. Most were applied across an entire sector or multiple sectors (i.e., the nonroad profiles were applied to the nonroad-related sector and the stationary profile was applied to the stationary-related sectors). A Minnesota facility and process-specific profile were added based on data provided by the state during the 2014v1 emissions review.

Table 3-22. Particle size speciation of Metals

Source Type	Profile	pollutant	Fine	coarse
Onroad	OARS	Arsenic	.95	.05

Source Type	Profile	pollutant	Fine	coarse
Onroad	ONMN	Manganese	.4375	.5625
Onroad	ONNI	Nickel	.83	.17
Onroad	CRON	Chromhex	.86	.14
Nonroad	NOARS	Arsenic	.83	.17
Nonroad	NONMN	Manganese	.67	.33
Nonroad	NONNI	Nickel	.49	.51
Nonroad	CRNR	Chromhex	.8	.2
Stationary	STANI	Nickel	.59	.41
Stationary	STACD	Cadmium	.76	.24
Stationary	STAMN	Manganese	.67	.33
Stationary	STAPB	Lead	.74	.26
Stationary	STABE	Beryllium	.68	.32
Stationary	CRSTA	Chromhex	.71	.29
Stationary	STARS	Arsenic	.59	.41
Stationary[1]	MNBE	Beryllium	.15	.85
Stationary[1]	MNCD	Cadmium	.15	.85
Stationary[1]	MNMN	Manganese	.15	.85
Stationary[1]	MNNI	Nickel	.15	.85
Stationary[1]	MNRS	Arsenic	.15	.85
Stationary[1]	CRMN	Chromhex	.15	.85

[1]Facility specific metal splits at United Taconite LLC - Thunderbird Mine facility in Minnesota as reported by Minnesota

For 2017 toxics modeling, mercury was speciated using new profiles , including unit-specific electric generating unit profiles (ptegu sector). Table 3-23 provides the mercury profiles used for sources using SCC-based speciation factors (EPA, 2020).

Table 3-23. Speciation of Mercury

Profile Code	Description	Elemental	Divalent Gas	Particulate
HGCEM	Cement kiln exhaust	0.66	0.34	0
HGCLI	Cement clinker cooler	0	0	1
HBCMB	Fuel combustion	0.5	0.4	0.1
HGCRE	Human cremation	0.8	0.15	0.05
HGELE	Elemental only (used?)	1	0	0
HGGEO	Geothermal power plants	0.87	0.13	0
HGGLD	Gold mining	0.8	0.15	0.05
HGHCL	Chlor-Alkali plants	0.972	0.028	0
HGINC	Waste incineration	0.2	0.6	0.2
HGIND	Industrial average	0.73	0.22	0.05
HGMD	Mobile diesel	0.56	0.29	0.15
HGMG	Mobile gas	0.915	0.082	0.003

HGMET	Metal production	0.8	0.15	0.005
HGMWI	Medical waste incineration	0.2	0.6	0.2
HGPETCOKE	Petroleum coke	0.6	0.3	0.1

3.3 Temporal Allocation

Temporal allocation is the process of distributing aggregated emissions to a finer temporal resolution, thereby converting annual emissions to hourly emissions as is required by CMAQ. While the total emissions are important, the timing of the occurrence of emissions is also essential for accurately simulating ozone, PM, and other pollutant concentrations in the atmosphere. Many emissions inventories are annual or monthly in nature. Temporal allocation takes these aggregated emissions and distributes the emissions to the hours of each day. This process is typically done by applying temporal profiles to the inventories in this order: monthly, day of the week, and diurnal, with monthly and day-of-week profiles applied only if the inventory is not already at that level of detail.

The temporal factors applied to the inventory are selected using some combination of country, state, county, SCC, and pollutant. Table 3-24 summarizes the temporal aspects of emissions modeling by comparing the key approaches used for temporal processing across the sectors. In the table, "Daily temporal approach" refers to the temporal approach for getting daily emissions from the inventory using the SMOKE Temporal program. The values given are the values of the SMOKE L_TYPE setting. The "Merge processing approach" refers to the days used to represent other days in the month for the merge step. If this is not "all," then the SMOKE merge step runs only for representative days, which could include holidays as indicated by the right-most column. The values given are those used for the SMOKE M_TYPE setting (see below for more information).

Table 3-24. Temporal settings used for the platform sectors in SMOKE

Platform sector short name	Inventory resolutions	Monthly profiles used?	Daily temporal approach	Merge processing approach	Process holidays as separate days
afdust_adj	Annual	Yes	week	All	Yes
airports	Annual	Yes	week	week	Yes
ag	Annual	Yes	all	all	Yes
beis	Hourly	No	n/a	All	No
cmv_c1c2	Annual	Yes	aveday	aveday	No
cmv_c3	Annual	Yes	aveday	aveday	No
nonpt	Annual	Yes	week	week	Yes
nonroad	Monthly	No	mwdss	Mwdss	Yes
np_oilgas	Annual	Yes	aveday	Aveday	No
onroad	Annual & monthly[1]	No	all	All	Yes
onroad_ca_adj	Annual & monthly[1]	No	all	All	Yes
othafdust_adj	Annual	Yes	week	All	No
othar	Annual & monthly	Yes	week	week	No
onroad_can	Monthly	No	week	week	No

Platform sector short name	Inventory resolutions	Monthly profiles used?	Daily temporal approach	Merge processing approach	Process holidays as separate days
onroad_mex	Monthly	No	week	week	No
othpt	Annual & monthly	Yes	mwdss	mwdss	No
othptdust_adj	Monthly	No	week	All	No
pt_oilgas	Annual	Yes	mwdss	mwdss	Yes
ptegu	Annual & hourly	Yes[2]	all	All	No
ptnonipm	Annual	Yes	mwdss	mwdss	Yes
ptagfire	Daily	No	all	All	No
ptfire	Daily	No	all	all	No
ptfire_othna	Daily	No	all	all	No
rail	Annual	Yes	aveday	aveday	No
rwc	Annual	No[3]	met-based[3]	all	No[3]

[1]Note the annual and monthly "inventory" actually refers to the activity data (VMT, hoteling, and VPOP) for onroad. VMT and hoteling is monthly and VPOP is annual. The actual emissions are computed on an hourly basis.

[2]Only units that do not have matching hourly CEMS data use monthly temporal profiles.

[3]Except for 2 SCCs that do not use met-based speciation

The following values are used in the table. The value "all" means that hourly emissions are computed for every day of the year and that emissions potentially have day-of-year variation. The value "week" means that hourly emissions computed for all days in one "representative" week, representing all weeks for each month. This means emissions have day-of-week variation, but not week-to-week variation within the month. The value "mwdss" means hourly emissions for one representative Monday, representative weekday (Tuesday through Friday), representative Saturday, and representative Sunday for each month. This means emissions have variation between Mondays, other weekdays, Saturdays and Sundays within the month, but not week-to-week variation within the month. The value "aveday" means hourly emissions computed for one representative day of each month, meaning emissions for all days within a month are the same. Special situations with respect to temporal allocation are described in the following subsections.

In addition to the resolution, temporal processing includes a ramp-up period for several days prior to January 1, 2017, which is intended to mitigate the effects of initial condition concentrations. The ramp-up period was 10 days (December 22-31, 2016). For all anthropogenic sectors, emissions from December 2017 were used to fill in surrogate emissions for the end of December 2016. For biogenic emissions, December 2016 emissions were computed using year 2016 meteorology.

3.3.1 Use of FF10 format for finer than annual emissions

The FF10 inventory format for SMOKE provides a consolidated format for monthly, daily, and hourly emissions inventories. With the FF10 format, a single inventory file can contain emissions for all 12 months and the annual emissions in a single record. This helps simplify the management of numerous inventories. Similarly, daily and hourly FF10 inventories contain individual records with data for all days in a month and all hours in a day, respectively.

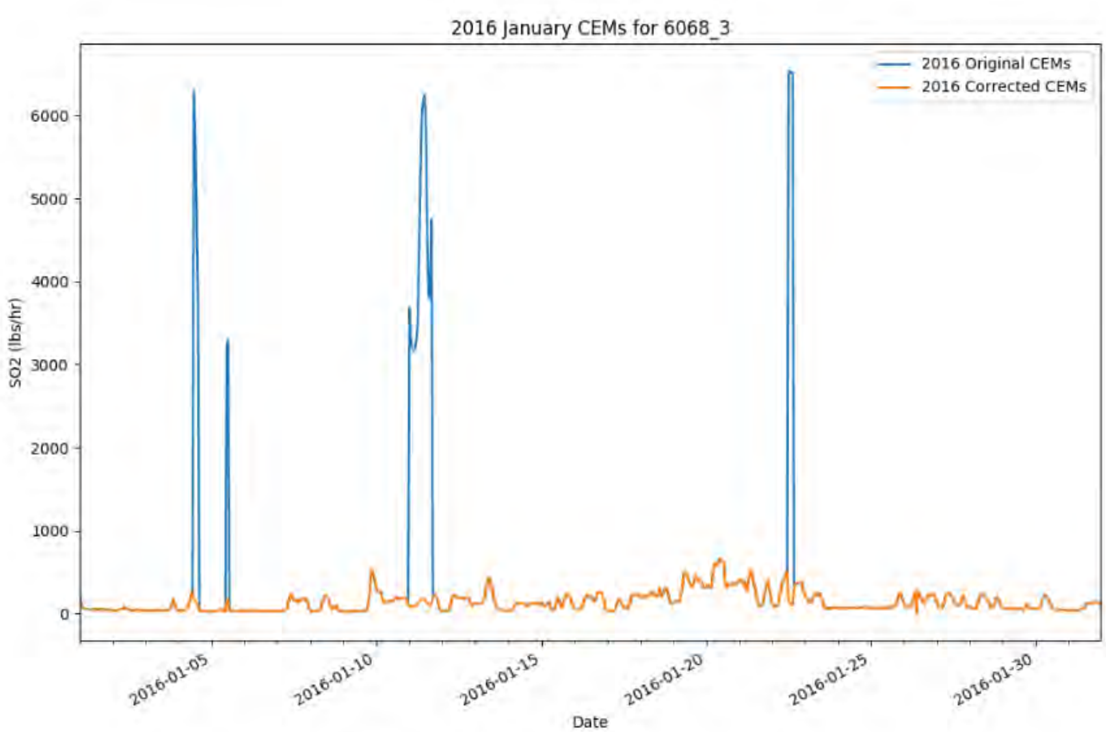
SMOKE prevents the application of temporal profiles on top of the "native" resolution of the inventory. For example, a monthly inventory should not have annual-to-month temporal allocation applied to it;

rather, it should only have month-to-day and diurnal temporal allocation. This becomes particularly important when specific sectors have a mix of annual, monthly, daily, and/or hourly inventories. The flags that control temporal allocation for a mixed set of inventories are discussed in the SMOKE documentation. The modeling platform sectors that make use of monthly values in the FF10 files are ag, nonroad, onroad, onroad_can, onroad_mex, othar, and othpt.

3.3.2 Electric Generating Utility temporal allocation (ptegu)

The temporal allocation procedure for EGUs in the base year is differentiated by whether or not the unit could be directly matched to a unit with CEMS data via its ORIS facility code and boiler ID. Note that for units matched to CEMS data, annual totals of their emissions input to CMAQ may be different than the annual values in the 2017 annual inventory because the CEMS data replaces the NO_x and SO_2 annual inventory data for the seasons in which the CEMS are operating. If a CEMS-matched unit is determined to be a partial year reporter, as can happen for sources that run CEMS only in the summer, emissions totaling the difference between the annual emissions and the total CEMS emissions are allocated to the non-summer months. Prior to use of the CEMS data in SMOKE it is processed through the CEMCorrect tool. The CEMCorrect tool identifies hours for which the data were not measured as indicated by the data quality flags in the CEMS data files. Unmeasured data can be filled in with maximum values and thereby cause erroneously high values in the CEMS data.   When data were flagged as unmeasured and the values were found to be more than three times the annual mean for that unit, the data for those hours are replaced with annual mean values (Adelman et al., 2012). These adjusted CEMS data were then used for the remainder of the temporal allocation process described below (see Figure 3-5 for an example).

Figure 3-5. Eliminating unmeasured spikes in CEMS data



In modeling platforms prior to 2016 beta, unmatched EGUs were temporally allocated using daily and diurnal profiles weighted by CEMS values within an IPM region, season, and by fuel type (coal, gas, and other). All unit types (peaking and non-peaking) were given the same profile within a region, season and fuel bin. Units identified as municipal waste combustors (MWCs) or cogeneration units (cogens) were given flat daily and diurnal profiles. Beginning with the 2016 beta platform and continuing for the 2016v1 and 2017 platforms, the small EGU temporalization process was improved to also consider peaking units.

The region, fuel, and type (peaking or non-peaking) were identified for each input EGU with CEMS data that are used for generating profiles. The identification of peaking units was based on hourly heat input data from the 2016 base year and the two previous years (2014 and 2015). The heat input was summed for each year. Equation 3-2 shows how the annual heat input value is converted from heat units (BTU/year) to power units (MW) using the unit-level heat rate (BTU/kWh) derived from the NEEDS v6 database. In Equation 3-3 a capacity factor is calculated by dividing the annual unit MW value by the NEEDS v6 unit capacity value (MW) multiplied by the hours in the year. A peaking unit was defined as any unit that had a maximum capacity factor of less than 0.2 for every year (2015, 2016, and 2017) and a 3-year average capacity factor of less than 0.1.

Annual Unit Power Output

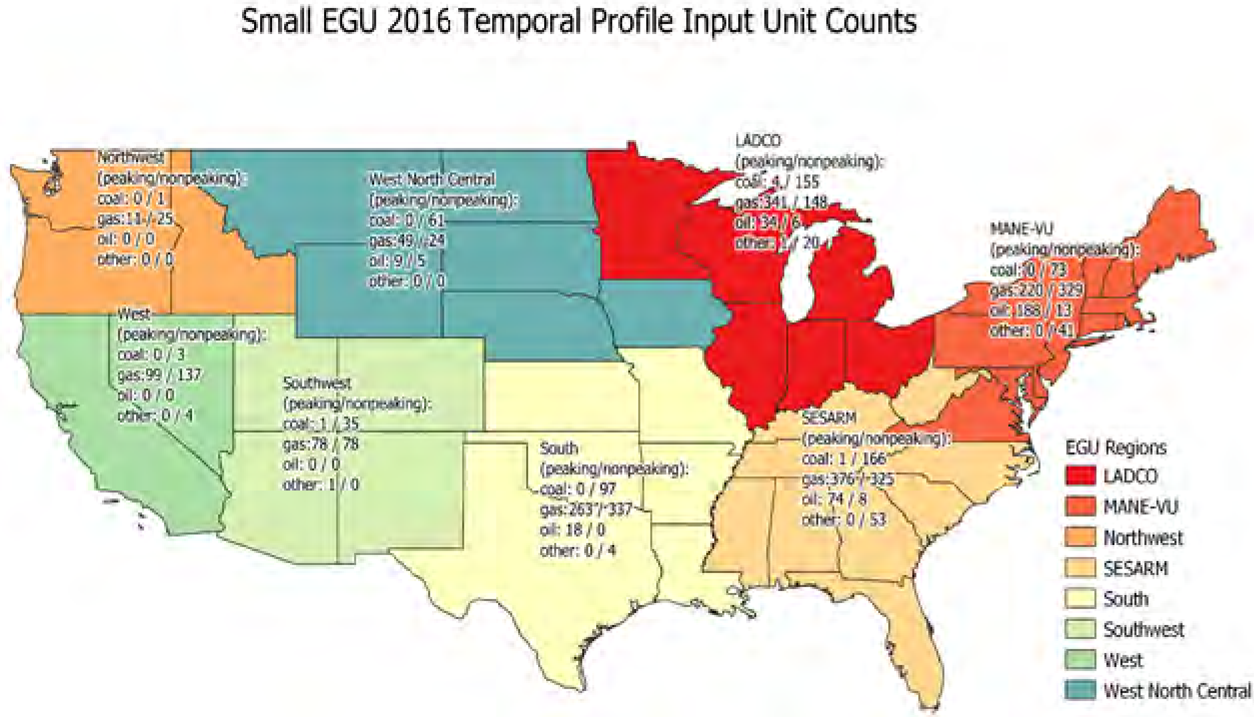
$$Annual\ Unit\ Output\ (MW) = \frac{\sum_{i=0}^{8760} \begin{matrix} Hourly\ HI \\ (BTU) \end{matrix} * 1000 \left(\frac{MW}{kW}\right)}{NEEDS\ Heat\ Rate\ \left(\frac{BTU}{kWh}\right)} \qquad \text{Equation 3-2}$$

Unit Capacity Factor

$$Capacity\ Factor = \frac{Annual\ Unit\ Output\ (MW)}{NEEDS\ Unit\ Capacity\ \left(\frac{MW}{h}\right) * 8760\ (h)} \qquad \text{Equation 3-3}$$

Input regions were determined from one of the eight EGU modeling regions based on MJO and climate regions. Regions were used to group units with similar climate-based load demands. Region assignment is made on a state level, where all units within a state were assigned to the appropriate region. Unit fuel assignments were made using the primary NEEDS v6 fuel. Units fueled by bituminous, subbituminous, or lignite are assigned to the coal fuel type. Natural gas units were assigned to the gas fuel type. Distillate and residual fuel oil were assigned to the oil fuel type. Units with any other primary fuel were assigned the “other” fuel type. The number of units used to calculate the daily and diurnal EGU temporal profiles are shown in Figure 3-6 by region, fuel, and for peaking/non-peaking. Currently there are 64 unique profiles available based on 8 regions, 4 fuels, and 2 for peaking unit status (peaking and non-peaking).

Figure 3-6. Temporal Profile Input Unit Counts by Fuel and Peaking Unit Classification



The daily and diurnal profiles were calculated for each region, fuel, and peaking type group from the year 2017 CEMS heat input values. The heat input values were summed for each input group to the annual level at each level of temporal resolution: monthly, month-of-day, and diurnal. The sum by temporal resolution value was then divided by the sum of annual heat input in that group to get a set of temporalization factors. Diurnal factors were created for both the summer and winter seasons to account for the variation in hourly load demands between the seasons. For example, the sum of all hour 1 heat input values in the group was divided by the sum of all heat inputs over all hours to get the hour 1 factor. Each grouping contained 12 monthly factors, up to 31 daily factors per month, and two sets of 24 hourly factors. The profiles were weighted by unit size where the units with more heat input have a greater influence on the shape of the profile. Composite profiles were created for each region and type across all fuels as a way to provide profiles for a fuel type that does not have hourly CEMS data in that region. Figure 3-7 shows peaking and non-peaking daily temporal profiles for the gas fuel type in the LADCO region. Figure 3-8 shows the diurnal profiles for the coal fuel type in the Mid-Atlantic Northeast Visibility Union (MANE-VU) region.

Figure 3-7. Example Daily Temporal Profiles for the LADCO Region and the Gas Fuel Type

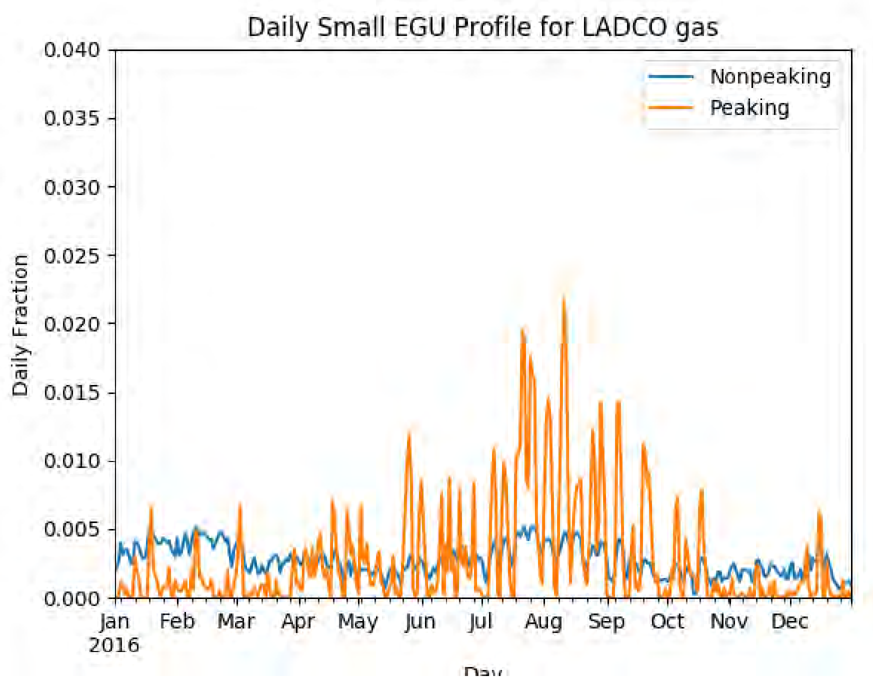
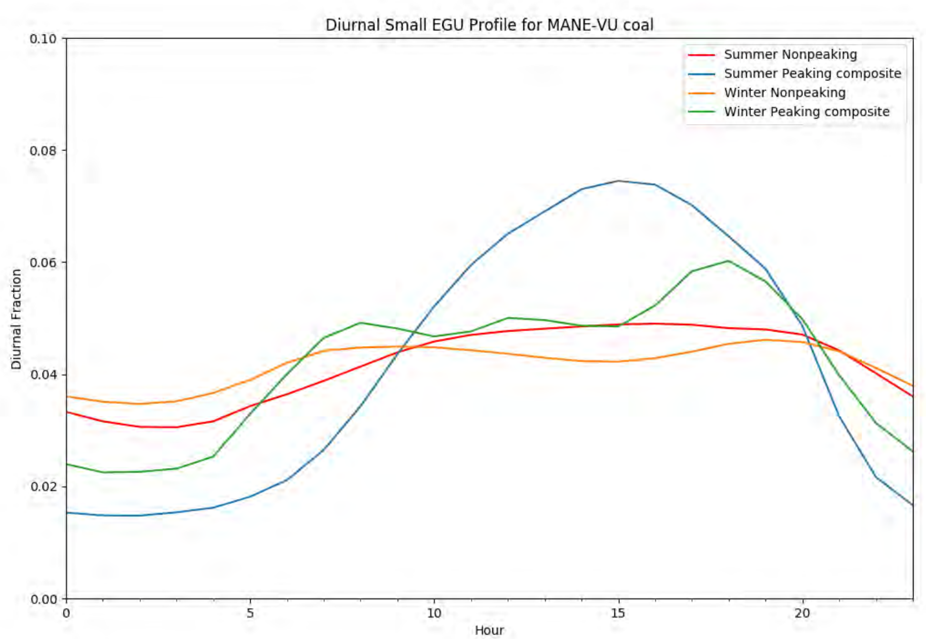
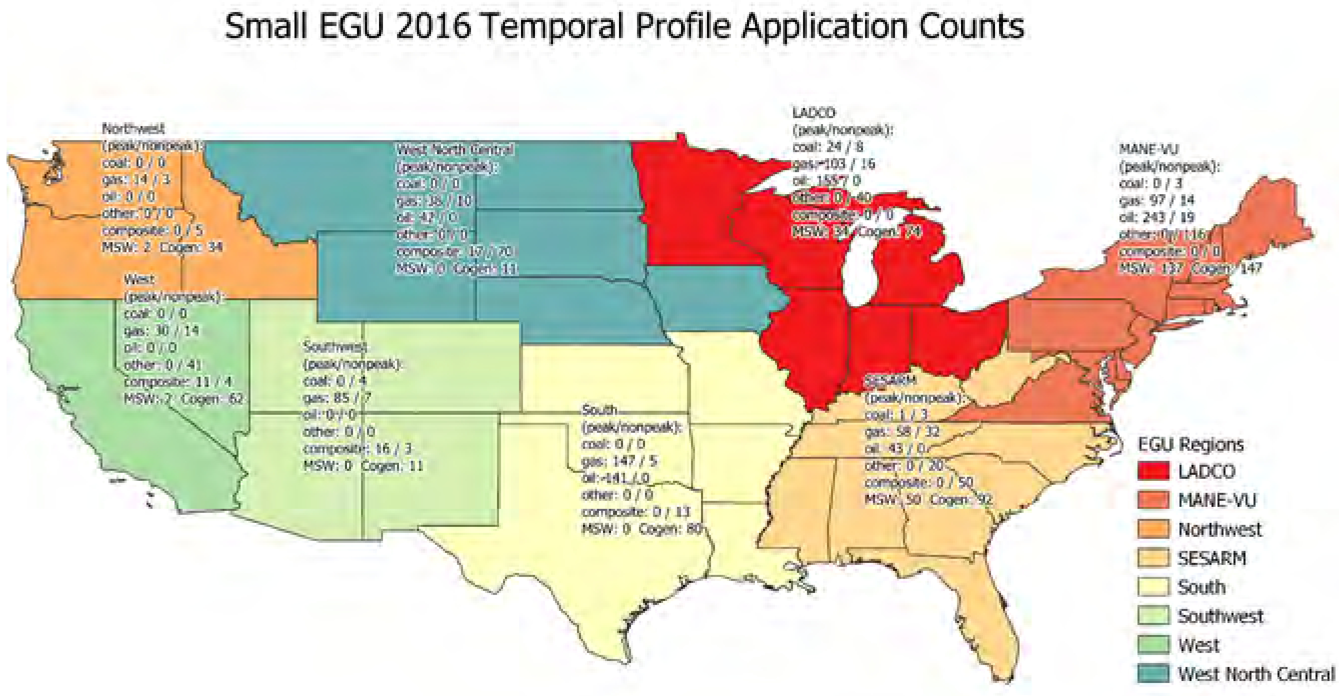


Figure 3-8. Example Diurnal Temporal Profiles for the MANE-VU Region and the Coal Fuel Type



SMOKE uses a cross-reference file to select a monthly, daily, and diurnal profile for each source. For the 2017 platform, the temporal profiles were assigned in the cross-reference at the unit level to EGU sources without hourly CEMS data. An inventory of all EGU sources without CEMS data was used to identify the region, fuel type, and type (peaking/non-peaking) of each source. As with the input unit the regions are assigned using the state from the unit FIPS. The fuel was assigned by SCC to one of the four fuel types: coal, gas, oil, and other. A fuel type unit assignment is made by summing the VOC, NOX, PM2.5, and SO2 for all SCCs in the unit. The SCC that contributed the highest total emissions to the unit for selected pollutants was used to assign the unit fuel type. Peaking units were identified as any unit with an oil, gas, or oil fuel type with a NAICS of 22111 or 221112. Some units may be assigned to a fuel type within a region that does not have an available input unit with a matching fuel type in that region. These units without an available profile for their group were assigned to use the regional composite profile. MWC and cogen units were identified using the NEEDS primary fuel type and cogeneration flag, respectively, from the NEEDS v6 database. The number of EGU units assigned each profile group are shown by region in Figure 3-9. In this plot, the unit counts are from 2016, but the 2017 unit counts should be similar.

Figure 3-9. Non-CEMS EGU Temporal Profile Application Counts



3.3.3 Airport Temporal allocation (airports)

Airport temporal profiles were updated in 2014v7.0 and were kept the same for this platform. All airport SCCs (i.e., 2275*, 2265008005, 2267008005, 2268008005 and 2270008005) were given the same hourly, weekly and monthly profile for all airports other than Alaska seaplanes (which are not in the CMAQ modeling domain). Hourly airport operations data were obtained from the Aviation System Performance Metrics (ASPM) Airport Analysis website (https://aspm.faa.gov/apm/sys/AnalysisAP.asp). A report of 2014 hourly Departures and Arrivals for Metric Computation was generated. An overview of the ASPM metrics is at http://aspmhelp.faa.gov/index.php/Aviation_Performance_Metrics_%28APM%29. Figure 3-10 shows the diurnal airport profile.

Weekly and monthly temporal profiles are based on 2014 data from the FAA Operations Network Air Traffic Activity System (http://aspm.faa.gov/opsnet/sys/Terminal.asp). A report of all airport operations (takeoffs and landings) by day for 2014 was generated. These data were then summed to month and day-of-week to derive the monthly and weekly temporal profiles shown in Figure 3-10, Figure 3-11, and Figure 3-12. An overview of the Operations Network data system is at http://aspmhelp.faa.gov/index.php/Operations_Network_%28OPSNET%29. The weekly and monthly profiles from 2014 are still used in this platform.

Alaska seaplanes, which are outside the CONUS domain use the monthly profile in Figure 3-13. These were assigned based on the facility ID.

Figure 3-10. Diurnal Profile for all Airport SCCs

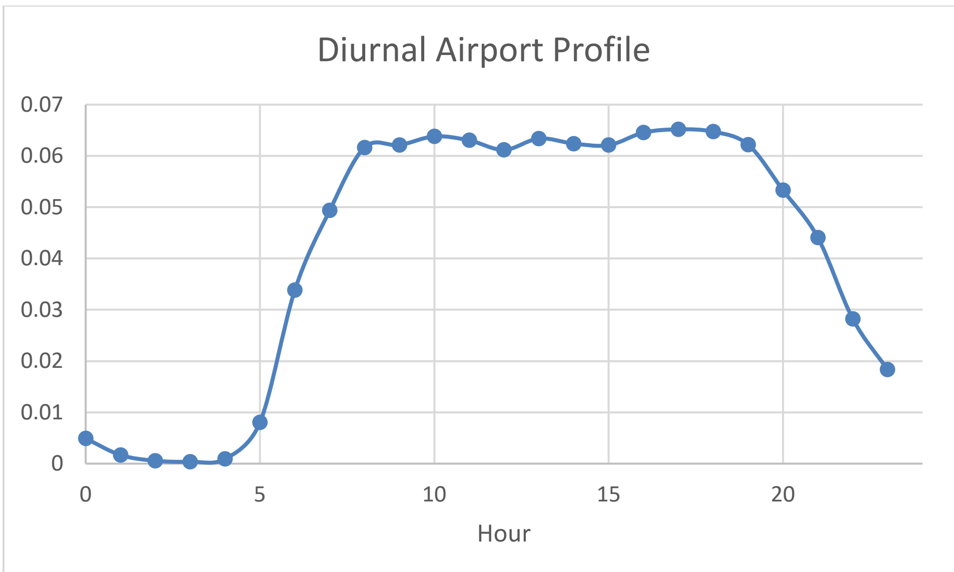


Figure 3-11. Weekly profile for all Airport SCCs

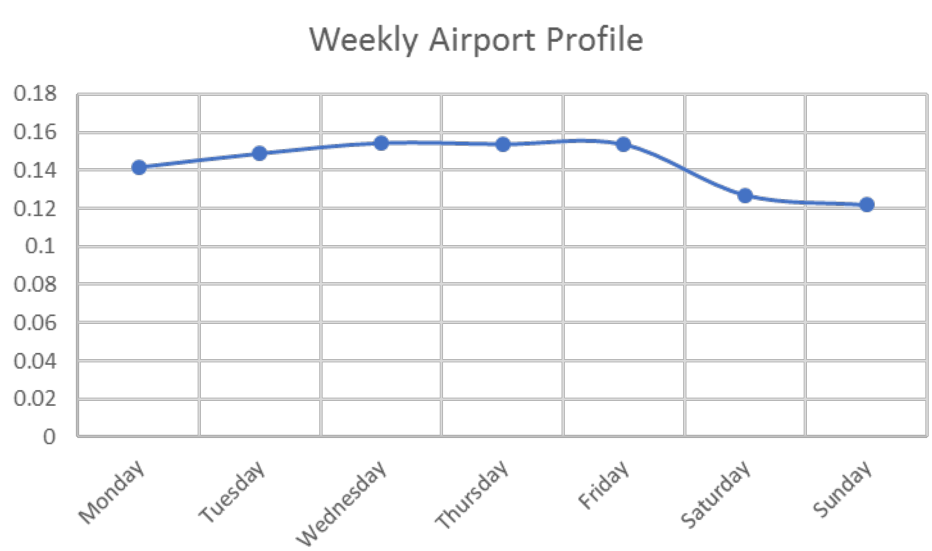


Figure 3-12. Monthly Profile for all Airport SCCs

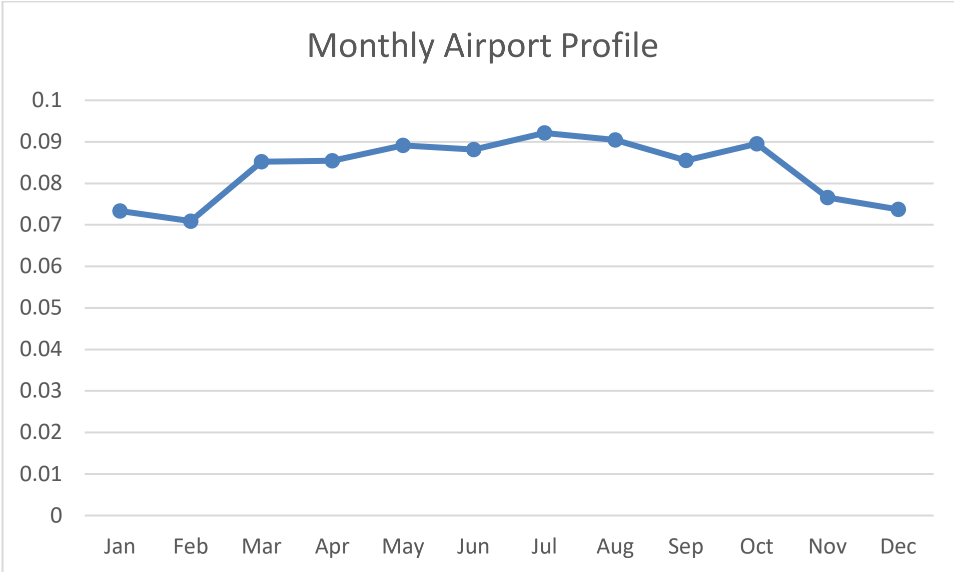
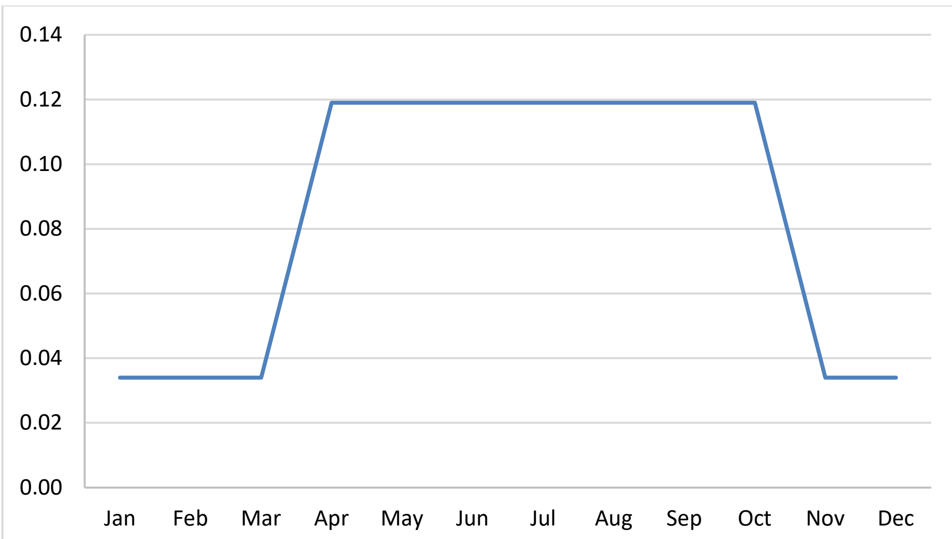


Figure 3-13. Alaska Seaplane Profile



3.3.4 Residential Wood Combustion Temporal allocation (rwc)

There are many factors that impact the timing of when emissions occur, and for some sectors this includes meteorology. The benefits of utilizing meteorology as a method for temporal allocation are: (1) a meteorological dataset consistent with that used by the AQ model is available (e.g., outputs from WRF); (2) the meteorological model data are highly resolved in terms of spatial resolution; and (3) the meteorological variables vary at hourly resolution and can, therefore, be translated into hour-specific temporal allocation.

The SMOKE program Gentpro provides a method for developing meteorology-based temporal allocation. Currently, the program can utilize three types of temporal algorithms: annual-to-day temporal allocation for residential wood combustion (RWC); month-to-hour temporal allocation for agricultural livestock

NH_3; and a generic meteorology-based algorithm for other situations. Meteorological-based temporal allocation was used for portions of the rwc sector and for the entire ag sector.

Gentpro reads in gridded meteorological data (output from MCIP) along with spatial surrogates and uses the specified algorithm to produce a new temporal profile that can be input into SMOKE. The meteorological variables and the resolution of the generated temporal profile (hourly, daily, etc.) depend on the selected algorithm and the run parameters. For more details on the development of these algorithms and running Gentpro, see the Gentpro documentation and the SMOKE documentation at http://www.cmascenter.org/smoke/documentation/3.1/GenTPRO_TechnicalSummary_Aug2012_Final.pdf and https://www.cmascenter.org/smoke/documentation/4.5/html/ch05s03s05.html, respectively.

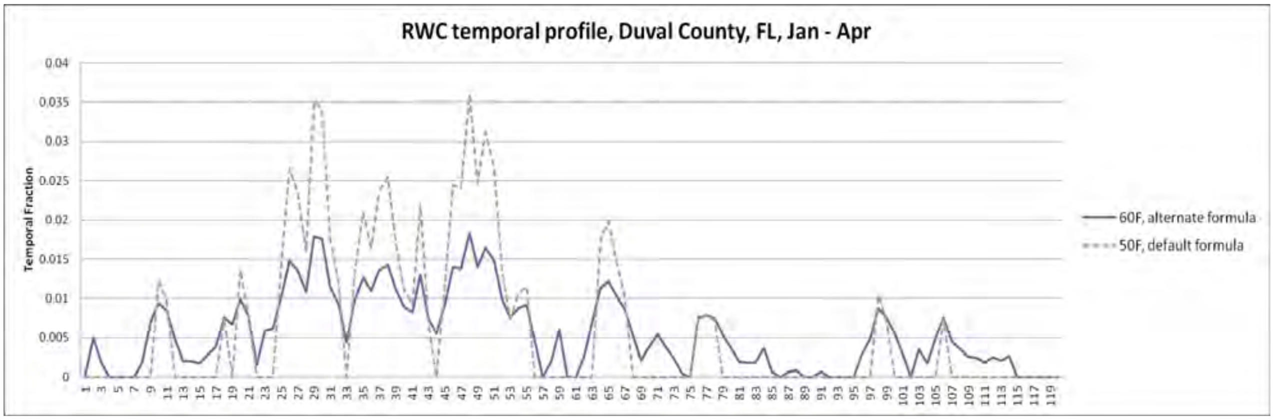
For the RWC algorithm, Gentpro uses the daily minimum temperature to determine the temporal allocation of emissions to days of the year. Gentpro was used to create an annual-to-day temporal profile for the RWC sources. These generated profiles distribute annual RWC emissions to the coldest days of the year. On days where the minimum temperature does not drop below a user-defined threshold, RWC emissions for most sources in the sector are zero. Conversely, the program temporally allocates the largest percentage of emissions to the coldest days. Similar to other temporal allocation profiles, the total annual emissions do not change, only the distribution of the emissions within the year is affected. The temperature threshold for RWC emissions was 50 ˚F for most of the country, and 60 ˚F for the following states: Alabama, Arizona, California, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. The algorithm is as follows:

> If Td >= Tt: no emissions that day
> If Td < Tt: daily factor = 0.79*(Tt -Td)
>
> where (Td = minimum daily temperature; Tt = threshold temperature, which is 60 degrees F in southern states and 50 degrees F elsewhere).

Once computed, the factors are normalized to sum to 1 to ensure that the total annual emissions are unchanged (or minimally changed) during the temporal allocation process.

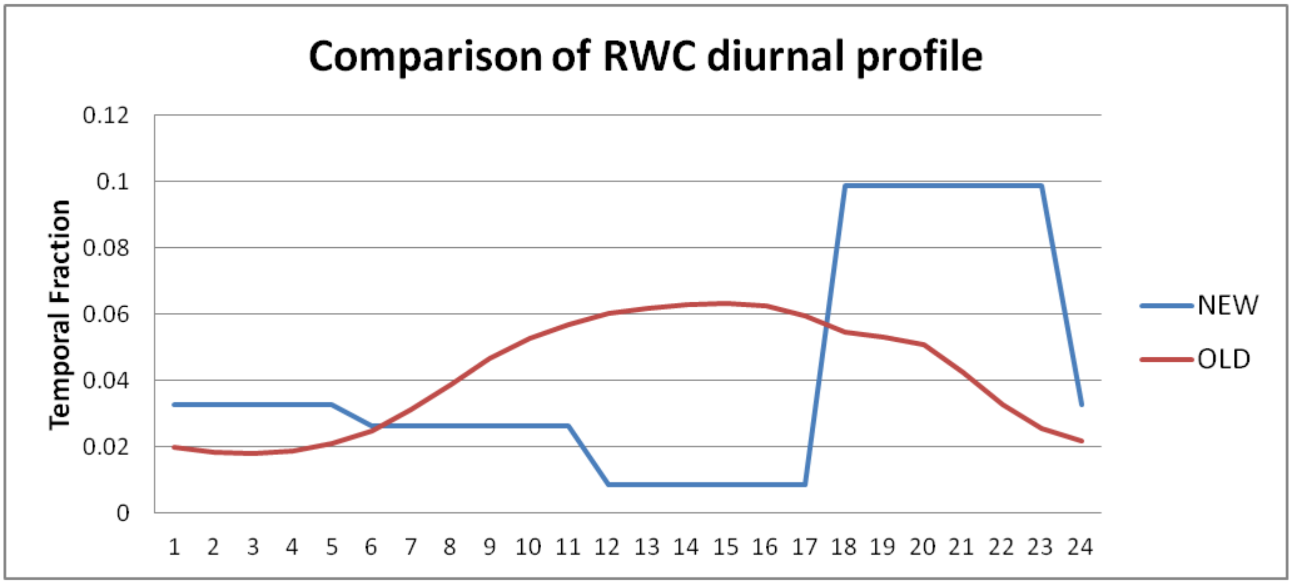
Figure 3-14 illustrates the impact of changing the temperature threshold for a warm climate county. The plot shows the temporal fraction by day for Duval County, Florida, for the first four months of 2007. The default 50 ˚F threshold creates large spikes on a few days, while the 60 ˚F threshold dampens these spikes and distributes a small amount of emissions to the days that have a minimum temperature between 50 and 60 ˚F.

Figure 3-14. Example of RWC temporal allocation in 2007 using a 50 versus 60 ˚F threshold



The diurnal profile used for most RWC sources (see Figure 3-15) places more of the RWC emissions in the morning and the evening when people are typically using these sources. This profile is based on a 2004 MANE-VU survey based temporal profiles (https://s3.amazonaws.com/marama.org/wp-content/uploads/2019/11/04184303/Open_Burning_Residential_Areas_Emissions_Report-2004.pdf). This profile was created by averaging three indoor and three RWC outdoor temporal profiles from counties in Delaware and aggregating them into a single RWC diurnal profile. This new profile was compared to a concentration-based analysis of aethalometer measurements in Rochester, New York (Wang *et al.* 2011) for various seasons and days of the week and was found that the new RWC profile generally tracked the concentration based temporal patterns.

Figure 3-15. RWC diurnal temporal profile



The temporal profiles for hydronic heaters" (i.e., SCCs=2104008610 [outdoor], 2104008620 [indoor], and 2104008620 [pellet-fired]) and "Outdoor wood burning device, NEC (fire-pits, chimeneas, etc.)" (i.e., "recreational RWC," SCC=2104008700) are not based on temperature data, because the meteorologically based temporal allocation used for the rest of the rwc sector did not agree with observations for how these appliances are used.

For hydronic heaters, the annual-to-month, day-of-week and diurnal profiles were modified based on information in the New York State Energy Research and Development Authority's (NYSERDA) "Environmental, Energy Market, and Health Characterization of Wood-Fired Hydronic Heater Technologies, Final Report" (NYSERDA, 2012), as well as a Northeast States for Coordinated Air Use Management (NESCAUM) report "Assessment of Outdoor Wood-fired Boilers" (NESCAUM, 2006). A Minnesota 2008 Residential Fuelwood Assessment Survey of individual household responses (MDNR, 2008) provided additional annual-to-month, day-of-week, and diurnal activity information for OHH as well as recreational RWC usage.

Data used to create the diurnal profile for hydronic heaters, shown in Figure 3-16, are based on a conventional single-stage heat load unit burning red oak in Syracuse, New York. As shown in Figure 3-17, the NESCAUM report describes how for individual units, OHH are highly variable day-to-day but that in the aggregate, these emissions have no day-of-week variation. In contrast, the day-of-week profile for recreational RWC follows a typical "recreational" profile with emissions peaked on weekends.

Annual-to-month temporal allocation for OHH as well as recreational RWC were computed from the MDNR 2008 survey and are illustrated in Figure 3-18. The hydronic heater emissions still exhibit strong seasonal variability, but do not drop to zero because many units operate year-round for water and pool heating. In contrast to all other RWC appliances, recreational RWC emissions are used far more frequently during the warm season.

Figure 3-16. Data used to produce a diurnal profile for hydronic heaters

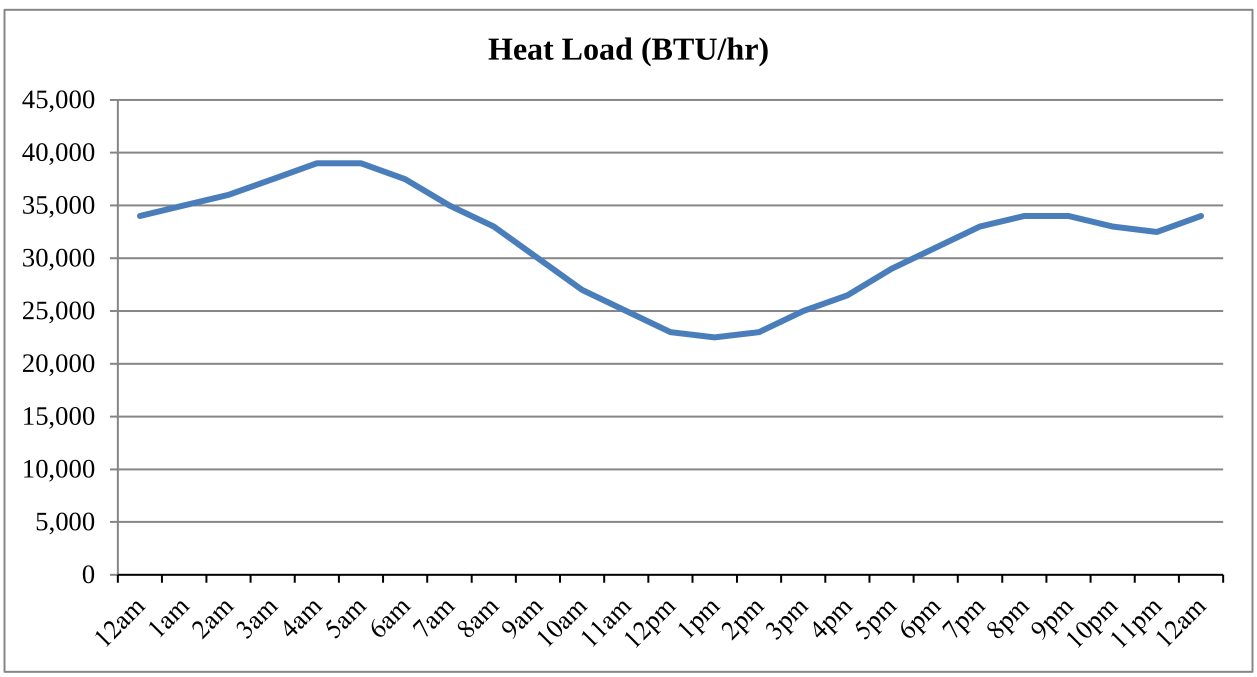


Figure 3-17. Day-of-week temporal profiles for hydronic heaters and recreational RWC

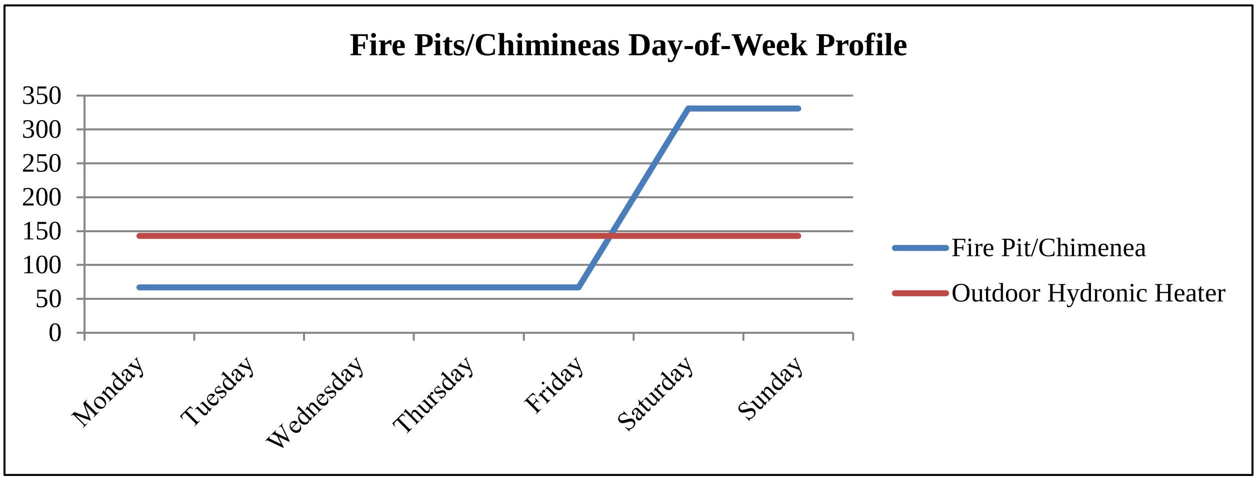
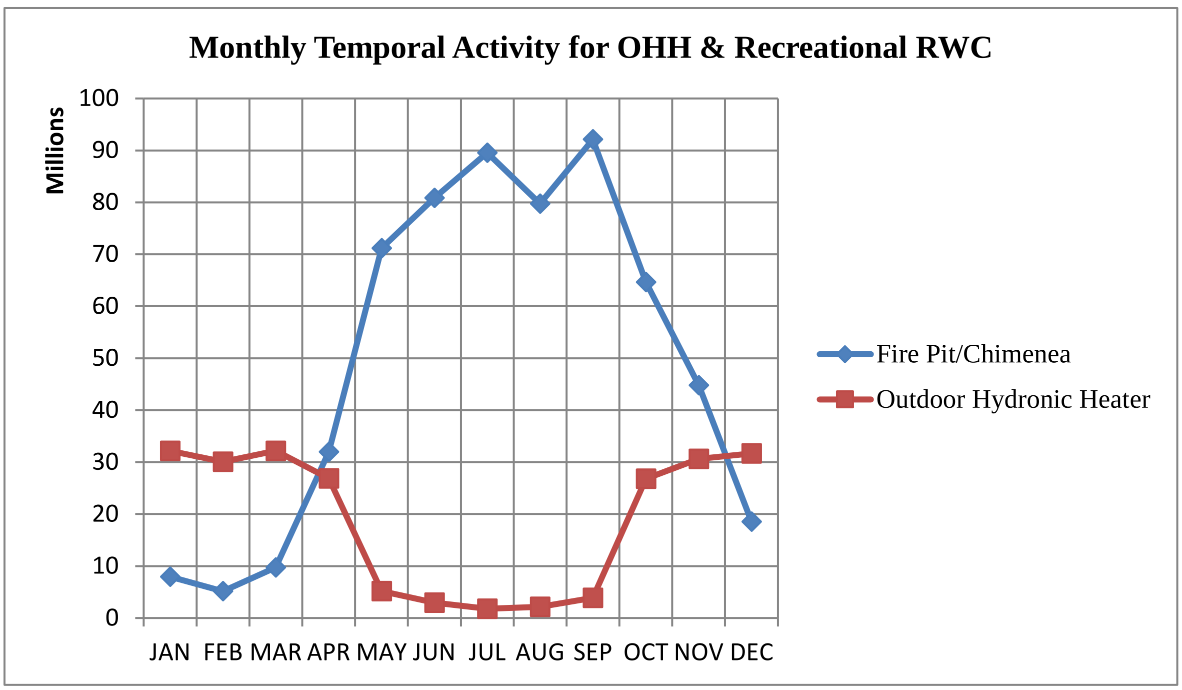


Figure 3-18. Annual-to-month temporal profiles for hydronic heaters and recreational RWC



3.3.5 Agricultural Ammonia Temporal Profiles (ag)

For the agricultural livestock NH_3 algorithm, the GenTPRO algorithm is based on an equation derived by Jesse Bash of the EPA's ORD based on the Zhu, Henze, et al. (2013) empirical equation. This equation is based on observations from the TES satellite instrument with the GEOS-Chem model and its adjoint to estimate diurnal NH_3 emission variations from livestock as a function of ambient temperature, aerodynamic resistance, and wind speed. The equations are:

$E_{i,h} = [161500/T_{i,h} \times e^{(-1380/T_{i,h})}] \times AR_{i,h}$ Equation 3-4

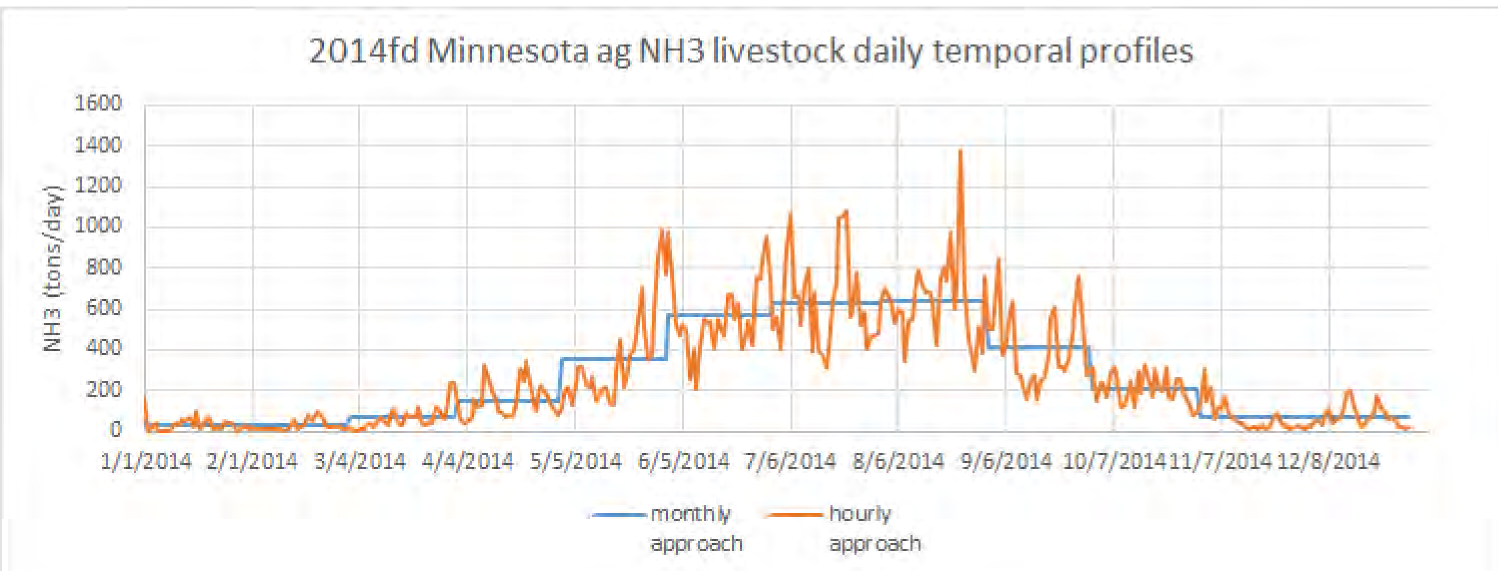
$PE_{i,h} = E_{i,h} / Sum(E_{i,h})$ Equation 3-5

where

- $PE_{i,h}$ = Percentage of emissions in county *i* on hour *h*
- $E_{i,h}$ = Emission rate in county *i* on hour *h*
- $T_{i,h}$ = Ambient temperature (Kelvin) in county *i* on hour *h*
- $AR_{i,h}$ = Aerodynamic resistance in county *i*

GenTPRO was run using the "BASH_NH3" profile method to create month-to-hour temporal profiles for these sources. Because these profiles distribute to the hour based on monthly emissions, the monthly emissions are obtained from a monthly inventory, or from an annual inventory that has been temporalized to the month. Figure 3-19 compares the daily emissions for Minnesota from the "old" approach (uniform monthly profile) with the "new" approach (GenTPRO generated month-to-hour profiles) for 2014. Although the GenTPRO profiles show daily (and hourly variability), the monthly total emissions are the same between the two approaches.

Figure 3-19. Example of animal NH_3 emissions temporal allocation approach (daily total emissions)



For this platform, the GenTPRO approach is applied to all sources in the ag sector, NH_3 and non- NH_3, livestock and fertilizer. Monthly profiles are based on the daily-based EPA livestock emissions and are the same as were used in 2014v7.0. Profiles are by state/SCC_category, where SCC_category is one of the following: beef, broilers, layers, dairy, swine.

3.3.6 Oil and gas temporal allocation (np_oilgas)

Monthly oil and gas temporal profiles by county and SCC were updated to use 2017 activity information for the 2017 platform. Weekly and diurnal profiles are flat and are based on comments received on a version of the 2011 platform.

3.3.7 Onroad mobile temporal allocation (onroad)

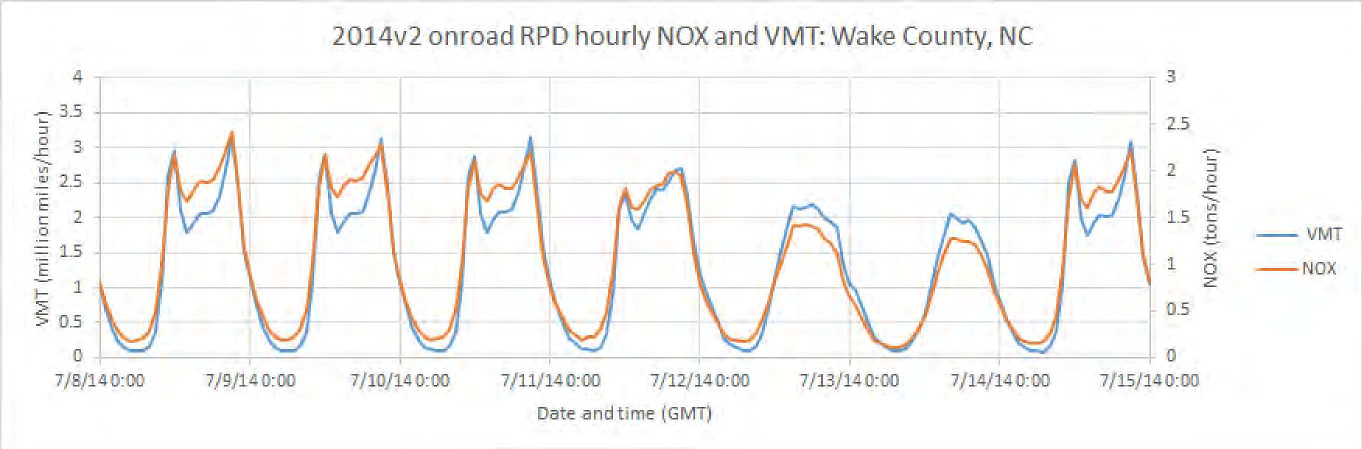
For the onroad sector, the temporal distribution of emissions is a combination of traditional temporal profiles and the influence of meteorology. This section will discuss both the meteorological influences and the development of the temporal profiles for this platform.

The "inventories" referred to in Table 3-24 consist of activity data for the onroad sector, not emissions. For the off-network emissions from the rate-per-profile (RPP) and rate-per-vehicle (RPV) processes, the VPOP activity data is annual and does not need temporal allocation. For rate-per-hour (RPH) processes that result from hoteling of combination trucks, the HOTELING inventory is annual and was temporalized to month, day of the week, and hour of the day through temporal profiles.

For on-roadway rate-per-distance (RPD) processes, the VMT activity data is annual for some sources and monthly for other sources, depending on the source of the data. Sources without monthly VMT were temporalized from annual to month through temporal profiles. VMT was also temporalized from month to day of the week, and then to hourly through temporal profiles. The RPD processes require a speed profile (SPDPRO) that consists of vehicle speed by hour for a typical weekday and weekend day. For onroad, the temporal profiles and SPDPRO will impact not only the distribution of emissions through time but also the total emissions. Because SMOKE-MOVES (for RPD) calculates emissions based on the VMT, speed and meteorology, if one shifted the VMT or speed to different hours, it would align with different temperatures and hence different emission factors. In other words, two SMOKE-MOVES runs with identical annual VMT, meteorology, and MOVES emission factors, will have different total emissions if the temporal allocation of VMT changes. Figure 3-20 illustrates the temporal allocation of the onroad activity data (i.e., VMT) and the pattern of the emissions that result after running SMOKE-MOVES. In this figure, it can be seen that the meteorologically varying emission factors add variation on top of the temporal allocation of the activity data.

Meteorology is not used in the development of the temporal profiles, but rather it impacts the calculation of the hourly emissions through the program Movesmrg. The result is that the emissions vary at the hourly level by grid cell. More specifically, the on-network (RPD) and the off-network parked vehicle (RPV, RPH, and RPP) processes use the gridded meteorology (MCIP) either directly or indirectly. For RPD, RPV, and RPH, Movesmrg determines the temperature for each hour and grid cell and uses that information to select the appropriate emission factor for the specified SCC/pollutant/mode combination. For RPP, instead of reading gridded hourly meteorology, Movesmrg reads gridded daily minimum and maximum temperatures. The total of the emissions from the combination of these four processes (RPD, RPV, RPH, and RPP) comprise the onroad sector emissions. The temporal patterns of emissions in the onroad sector are influenced by meteorology.

Figure 3-20. Example of temporal variability of NO_X emissions



New VMT day-of-week and hour-of-day temporal profiles were developed for use in the 2014NEIv2 and later platforms as part of the effort to update the inputs to MOVES and SMOKE-MOVES under CRC A-100 (Coordinating Research Council, 2017). CRC A-100 data includes profiles by region or county, road type, and broad vehicle category. There are three vehicle categories: passenger vehicles (11/21/31), commercial trucks (32/52), and combination trucks (53/61/62). CRC A-100 does not cover buses, refuse trucks, or motor homes, so those vehicle types were mapped to other vehicle types for which CRC A-100 did provide profiles as follows: 1) Intercity/transit buses were mapped to commercial trucks; 2) Motor homes were mapped to passenger vehicles for day-of-week and commercial trucks for hour-of-day; 3) School buses and refuse trucks were mapped to commercial trucks for hour-of-day and use a new custom day-of-week profile called LOWSATSUN that has a very low weekend allocation, since school buses and refuse trucks operate primarily on business days. In addition to temporal profiles, CRC A-100 data were also used to develop the average hourly speed data (SPDPRO) used by SMOKE-MOVES. In areas where CRC A-100 data does not exist, hourly speed data is based on MOVES county databases.

The CRC A-100 dataset includes temporal profiles for individual counties, Metropolitan Statistical Areas (MSAs), and entire regions (e.g., West, South). For counties without county or MSA temporal profiles specific to itself, regional temporal profiles are used. Temporal profiles also vary by each of the MOVES road types, and there are distinct hour-of-day profiles for each day of the week. Plots of hour-of-day profiles for passenger vehicles in Fulton County, GA, are shown in Figure 3-21. Separate plots are shown for Monday, Friday, Saturday, and Sunday, and each line corresponds to a particular MOVES road type (i.e., road type 2 = rural restricted, 3 = rural unrestricted, 4 = urban restricted, and 5 = urban unrestricted). Figure 3-22 shows which counties have temporal profiles specific to that county, and which counties use MSA or regional average profiles. Figure 3-23 shows the regions used for each of the regional average profiles.

Figure 3-21. Sample onroad diurnal profiles for Fulton County, GA

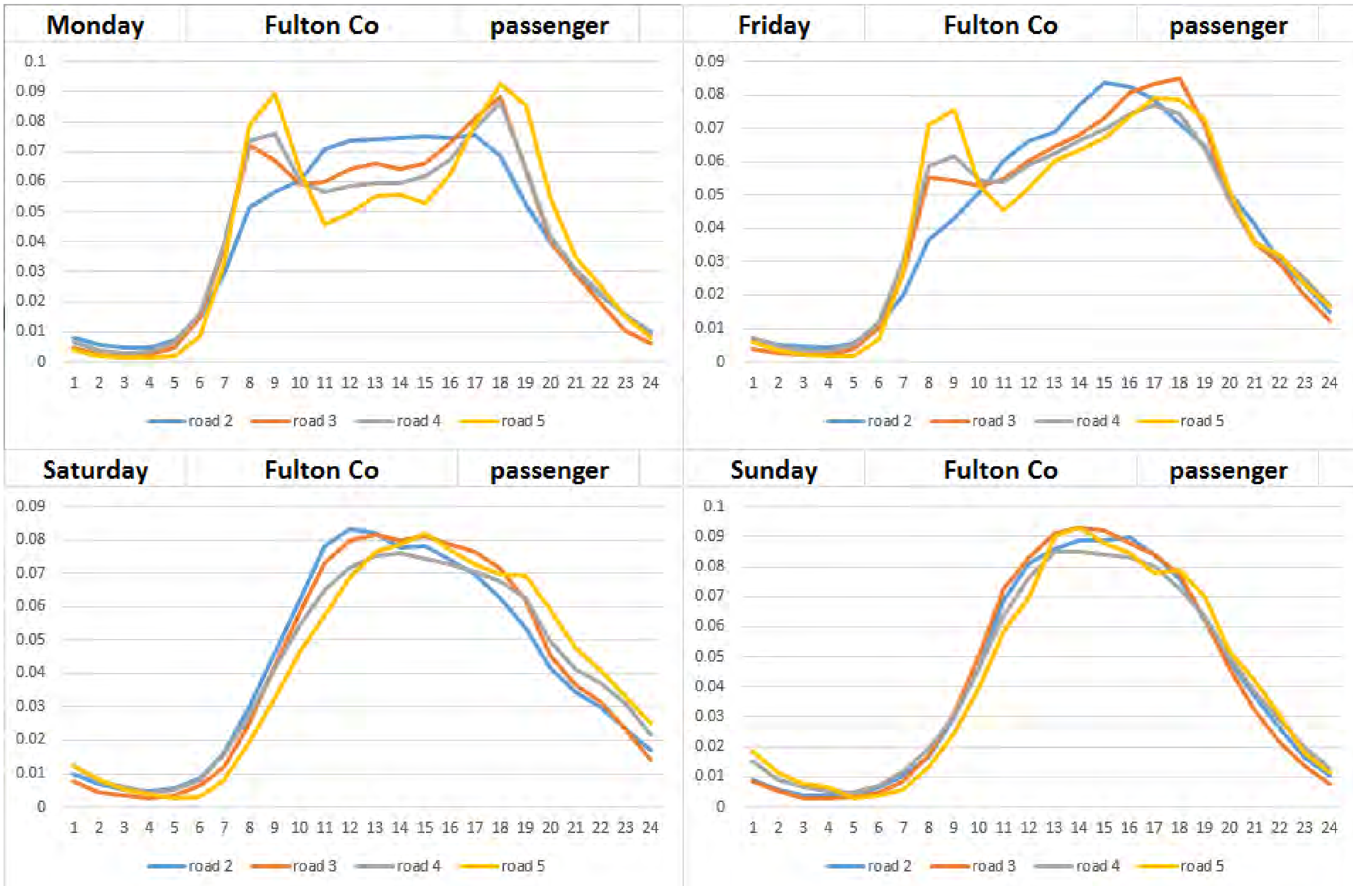
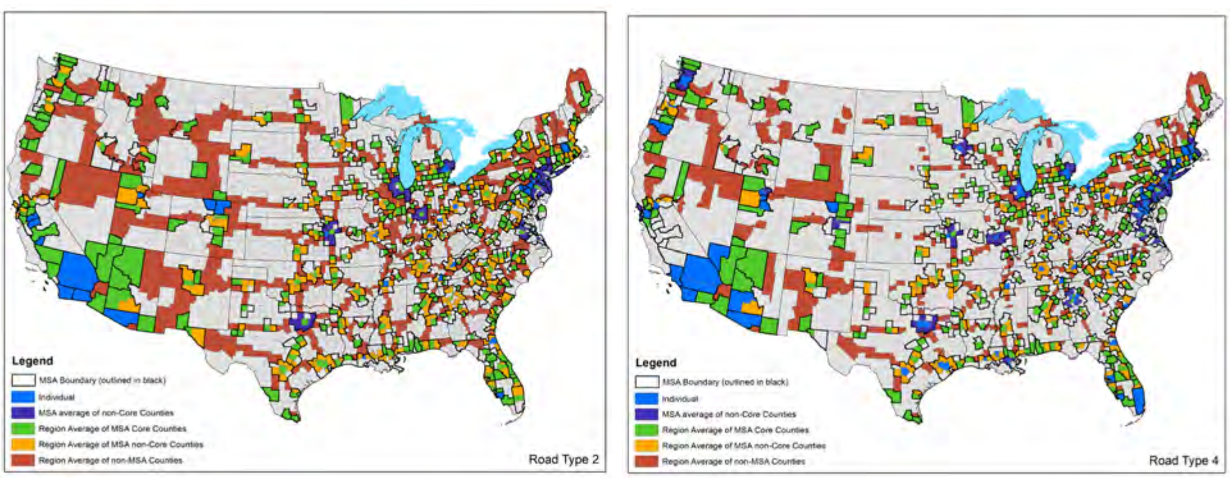


Figure 3-22. Methods to Populate Onroad Speeds and Temporal Profiles by Road Type



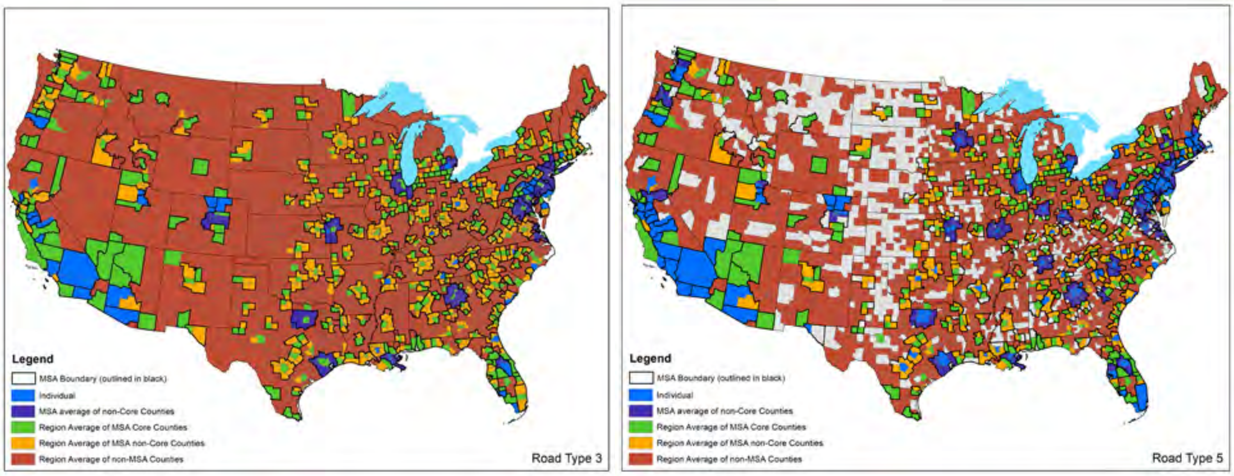
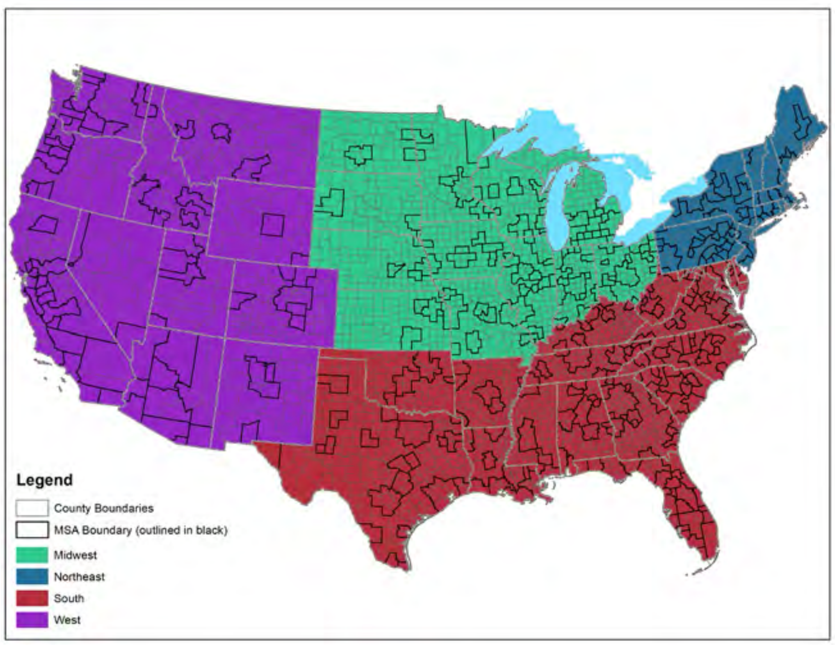


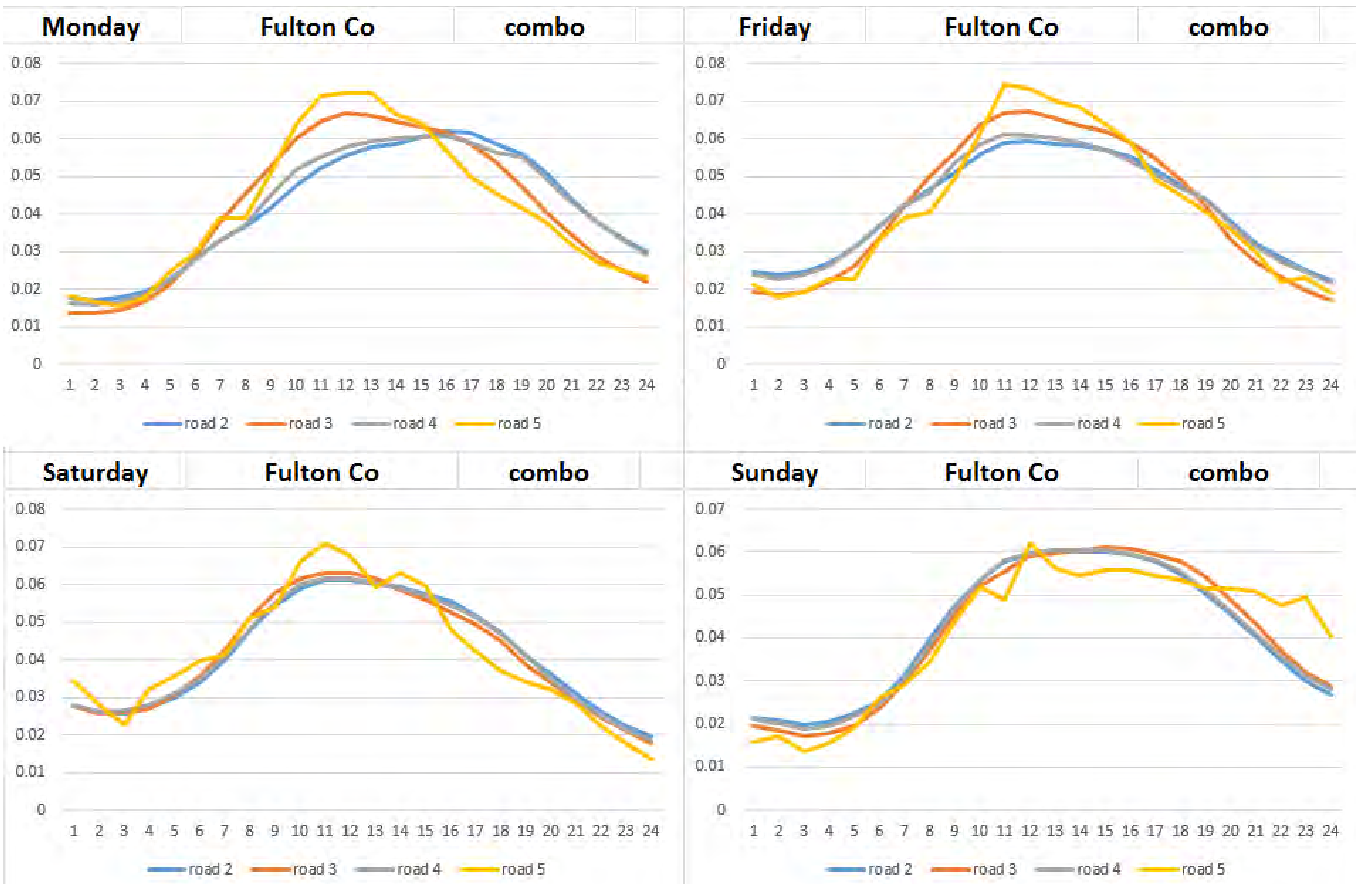
Figure 3-23. Regions for computing Region Average Speeds and Temporal Profiles



The CRC A-100 temporal profiles were used in areas of the contiguous United States that did not submit temporal profiles of sufficient detail for the 2017 NEI. For this platform, CRC A-100 profiles are used in most of the country, but day-of-week and hour-of-day profiles based on MOVES CDB submissions for the 2017NEI are used in Maricopa and Pima counties in Arizona, Delaware, Washington DC, Florida, some of Georgia, Idaho, Massachusetts, Maryland, Missouri, Clark County Nevada, New Jersey, New York, Ohio, Pennsylvania, Davidson and Knox counties in Tennessee, Texas, and Virginia.. All California temporal profiles were carried over from 2014v7.0 platform, although California hoteling uses CRC A-100-based profiles just like the rest of the country, since CARB didn't have a hoteling-specific profile. Monthly profiles in all states (national profiles by broad vehicle type) were also carried over from 2014v7.0 and applied directly to the VMT. For California, CARB supplied diurnal profiles that varied by vehicle type, day of the week,[26] and air basin. These CARB-specific profiles were used in developing EPA estimates for California. Although the EPA adjusted the total emissions to match California-submitted emissions, the temporal allocation of these emissions considered both the state-specific VMT profiles and the SMOKE-MOVES process of incorporating meteorology.

For hoteling, day-of-week profiles are the same as non-hoteling for combination trucks, while hour-of-day non-hoteling profiles for combination trucks were inverted to create new hoteling profiles that peak overnight instead of during the day. The combination truck profiles for Fulton County are shown in Figure 3-24.

Figure 3-24. Example of Temporal Profiles for Combination Trucks



3.3.8 Nonroad mobile temporal allocation (nonroad)

For nonroad mobile sources, temporal allocation is performed differently for different SCCs. Beginning with the final 2011 platform and continuing in the 2016 platform, improvements to temporal allocation of nonroad mobile sources were made to make the temporal profiles more realistically reflect real-world practices. Some specific updates were made for agricultural sources (e.g., tractors), construction, and commercial residential lawn and garden sources.

[26] California's diurnal profiles varied within the week. Monday, Friday, Saturday, and Sunday had unique profiles and Tuesday, Wednesday, Thursday had the same profile.

Figure 3-25 shows two previously existing temporal profiles (9 and 18) and a newer temporal profile (19) which has lower emissions on weekends. In this platform, construction and commercial lawn and garden sources use the new profile 19 which has lower emissions on weekends. Residental lawn and garden sources continue to use profile 9 and agricultural sources continue to use profile 19.

Figure 3-25. Example Nonroad Day-of-week Temporal Profiles

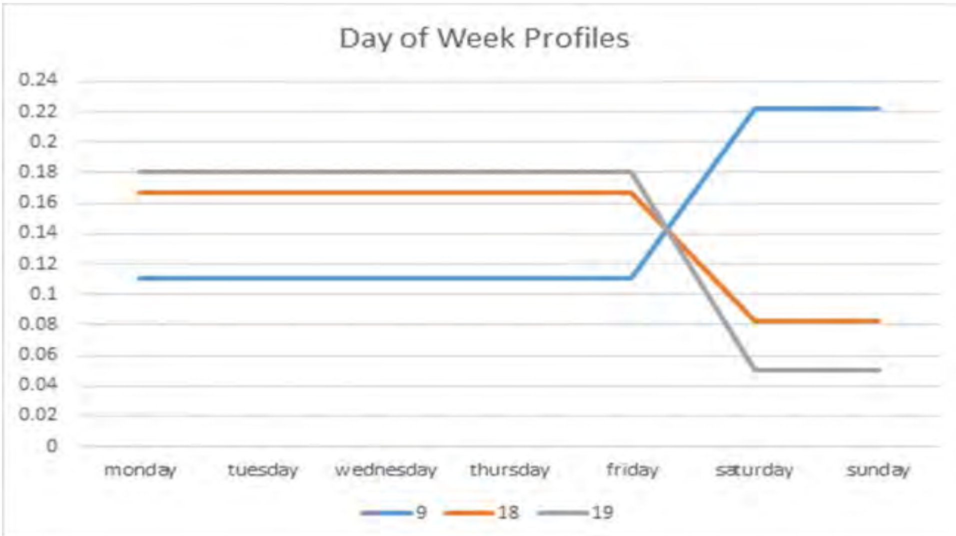
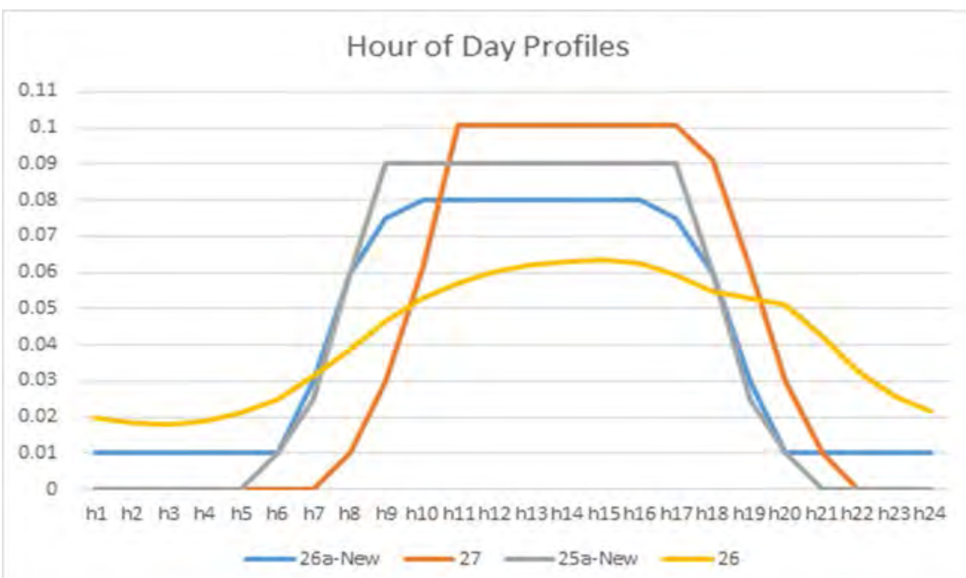


Figure 3-26 shows the previously existing temporal profiles 26 and 27 along with newer temporal profiles (25a and 26a) which have lower emissions overnight. In this platform, construction sources use profile 26a. Commercial lawn and garden and agriculture sources use the profiles 26a and 25a, respectively. Residental lawn and garden sources use profile 27.

Figure 3-26. Example Nonroad Diurnal Temporal Profiles



3.3.9 Additional sector specific details (afdust, beis, cmv, rail, nonpt, ptnonipm, ptfire)

For the afdust sector, meteorology is not used in the development of the temporal profiles, but it is used to reduce the total emissions based on meteorological conditions. These adjustments are applied through sector-specific scripts, beginning with the application of land use-based gridded transport fractions and then subsequent zero-outs for hours during which precipitation occurs or there is snow cover on the ground. The land use data used to reduce the NEI emissions explains the amount of emissions that are subject to transport. This methodology is discussed in (Pouliot et al., 2010), and in "Fugitive Dust Modeling for the 2008 Emissions Modeling Platform" (Adelman, 2012). The precipitation adjustment is applied to remove all emissions for hours where measurable rain occurs, or where there is snow cover. Therefore, the afdust emissions vary day-to-day based on the precipitation and/or snow cover for each grid cell and hour. Both the transport fraction and meteorological adjustments are based on the gridded resolution of the platform; therefore, somewhat different emissions will result from different grid resolutions. Application of the transport fraction and meteorological adjustments prevents the overestimation of fugitive dust impacts in the grid modeling as compared to ambient samples.

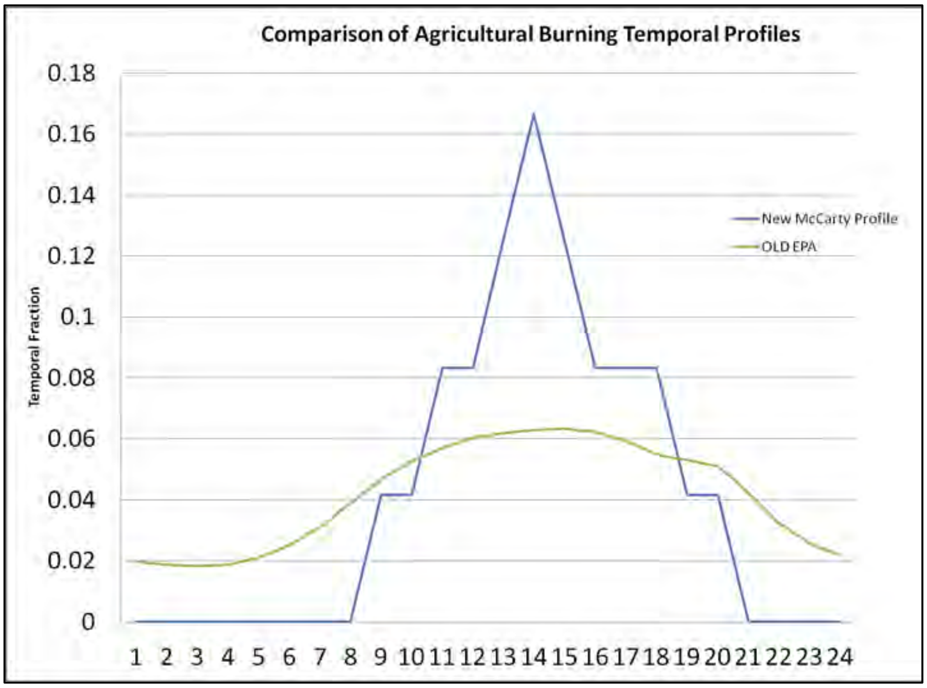
Biogenic emissions from the BEIS model vary each day of the year because they are developed using meteorological data including temperature, surface pressure, and radiation/cloud data. The emissions are computed using appropriate emission factors according to the vegetation in each model grid cell, while taking the meteorological data into account.

For the cmv sectors, most areas use hourly emission inventories derived from the 5-minute AIS data. In some areas where AIS data are not available, such as in Canada between the St. Lawrence Seaway and the Great Lakes and in the southern Caribbean, the flat temporal profiles are used for hourly and day-of-week values. Most regions without AIS data also use a flat monthly profile, with some offshore areas using an average monthly profile derived from the 2008 ECA inventory monthly values. These areas without AIS data also use flat day of week and hour of day profiles.

For the rail sector, new monthly profiles were developed for the 2016 platform. Monthly temporal allocation for rail freight emissions is based on AAR Rail Traffic Data, Total Carloads and Intermodal, for 2016. For passenger trains, monthly temporal allocation is flat for all months. Rail passenger miles data is available by month for 2016 but it is not known how closely rail emissions track with passenger activity since passenger trains run on a fixed schedule regardless of how many passengers are aboard, and so a flat profile is chosen for passenger trains. Rail emissions are allocated with flat day of week profiles, and most emissions are allocated with flat hourly profiles.

For the ptagfire sector, the inventories are in the daily point fire format FF10 PTDAY. The diurnal temporal profile for ag fires reflects the fact that burning occurs during the daylight hours - see Figure 3-27 (McCarty et al., 2009). This puts most of the emissions during the work day and suppresses the emissions during the middle of the night.

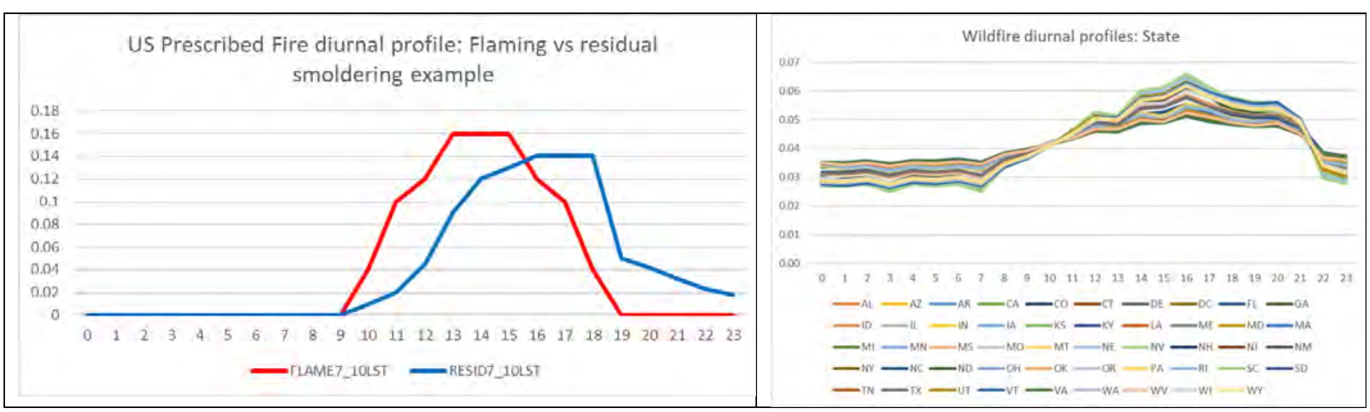
Figure 3-27. Agricultural burning diurnal temporal profile



Industrial processes that are not likely to shut down on Sundays, such as those at cement plants, use profiles that include emissions on Sundays, while those that would shut down on Sundays use profiles that reflect Sunday shutdowns.

For the ptfire sectors, the inventories are in the daily point fire format FF10 PTDAY. Separate hourly profiles for prescribed and wildfires were used. Figure 3-28 below shows the profiles used for each state for the platform. The wildfire diurnal profiles are similar but vary according to the average meteorological conditions in each state.

Figure 3-28. Prescribed and Wildfire diurnal temporal profiles



For the nonroad sector, while the NEI only stores the annual totals, the modeling platform uses monthly inventories from output from MOVES. For California, CARB's annual inventory was temporalized to monthly using monthly temporal profiles applied in SMOKE by SCC. This is an improvement over the 2011 platform, which applied monthly temporal allocation in California at the broader SCC7 level.

3.4 Spatial Allocation

The methods used to perform spatial allocation are summarized in this section. For the modeling platform, spatial factors are typically applied by county and SCC. As described in Section 3.1, spatial allocation was performed for the 12-km domain. To accomplish this, SMOKE used national 36-km and 12-km spatial surrogates and a SMOKE area-to-point data file. For the U.S., the EPA updated surrogates to use circa 2014 to 2017 data wherever possible. For Mexico, updated spatial surrogates were used as described below. For Canada, updated surrogates were provided by Environment Canada for the 2016v7.2 platform. The U.S., Mexican, and Canadian 36-km and 12-km surrogates cover the entire CONUS domain 12US1 shown in Figure 3-1. The 36US3 domain includes a portion of Alaska, and since Alaska emissions are typically not included in air quality modeling, special considerations are taken to include Alaska emissions in 36-km modeling.

Documentation of the origin of the spatial surrogates for the platform is provided in the workbook US_SpatialSurrogate_Workbook_v07172018 which is available with the reports for the 2014v7.1 platform. The remainder of this subsection summarizes the data used for the spatial surrogates and the area-to-point data which is used for airport refueling.

3.4.1 Spatial Surrogates for U.S. emissions

There are more than 100 spatial surrogates available for spatially allocating U.S. county-level emissions to the 36-km and 12-km grid cells used by the air quality model. As described in Section 3.4.2, an area-to-point approach overrides the use of surrogates for an airport refueling sources. Table 3-25 lists the codes and descriptions of the surrogates. Surrogate names and codes listed in *italics* are not directly assigned to any sources for the 2017 platform, but they are sometimes used to gapfill other surrogates, or as an input for merging two surrogates to create a new surrogate that is used.

Many surrogates were updated or newly developed for use in the 2014v7.0 platform (Adelman, 2016). They include the use of the 2011 National Land Cover Database (the previous platform used 2006) and development of various development density levels such as open, low, medium high and various combinations of these. These landuse surrogates largely replaced the FEMA category (500 series) surrogates that were used in the 2011 platform. Additionally, onroad surrogates were developed using average annual daily traffic counts from the highway monitoring performance system (HPMS). Previously, the “activity” for the onroad surrogates was length of road miles. This and other surrogates are described in a reference (Adelman, 2016).

Several surrogates were updated or developed as new surrogates for the 2016 and 2017 platforms:

- Oil and gas surrogates were updated to represent 2017;
- Onroad spatial allocation uses surrogates that do not distinguish between urban and rural road types, correcting the issue arising in some counties due to the inconsistent urban and rural definitions between MOVES and the surrogate data;
- New onroad surrogates were generated to incorporate 2017 Average Annual Daily Traffic (AADT);

- Spatial surrogates 201 through 244, which concern road miles, annual average daily traffic (AADT), and truck stops, were updated for the 2017 platform.
- A correction was made to the water surrogate to gap fill missing counties using the 2006 National Land Cover Database (NLCD).

The surrogates for the U.S. were mostly generated using the Surrogate Tool to drive the Spatial Allocator, but some surrogates were developed directly within ArcGIS or using the Surrogate Tools. The tool and documentation for the original Surrogate Tool are available at https://www.cmascenter.org/sa-tools/documentation/4.2/SurrogateToolUserGuide_4_2.pdf, and the tool and documentation for the Surrogate Tools DB is available from https://www.cmascenter.org/surrogate_tools_db/.

Table 3-25. U.S. Surrogates available for the 2017 modeling platforms

Code	Surrogate Description	Code	Surrogate Description
N/A	Area-to-point approach (see 3.6.2)	650	Refineries and Tank Farms
100	Population	670	Spud Count - CBM Wells
110	*Housing*	671	Spud Count - Gas Wells
150	Residential Heating - Natural Gas	672	Gas Production at Oil Wells
170	Residential Heating - Distillate Oil	*673*	*Oil Production at CBM Wells*
180	Residential Heating – Coal	674	Unconventional Well Completion Counts
190	Residential Heating - LP Gas	*676*	*Well Count - All Producing*
205	Extended Idle Locations	*677*	*Well Count - All Exploratory*
239	Total Road AADT	678	Completions at Gas Wells
240	Total Road Miles	679	Completions at CBM Wells
242	All Restricted AADT	681	Spud Count - Oil Wells
244	All Unrestricted AADT	683	Produced Water at All Wells
258	Intercity Bus Terminals	6831	Produced Water at CBM Wells
259	Transit Bus Terminals	6832	Produced Water at Gas Wells
260	*Total Railroad Miles*	6833	Produced Water at Oil Wells
261	NTAD Total Railroad Density	685	Completions at Oil Wells
271	NTAD Class 1 2 3 Railroad Density	*686*	*Completions at All Wells*
300	NLCD Low Intensity Development	687	Feet Drilled at All Wells
304	NLCD Open + Low	691	Well Counts - CBM Wells
305	NLCD Low + Med	692	Spud Count - All Wells
306	NLCD Med + High	693	Well Count - All Wells
307	NLCD All Development	694	Oil Production at Oil Wells
308	NLCD Low + Med + High	695	Well Count - Oil Wells
309	NLCD Open + Low + Med	696	Gas Production at Gas Wells
310	NLCD Total Agriculture	697	Oil Production at Gas Wells
319	NLCD Crop Land	698	Well Count - Gas Wells
320	NLCD Forest Land	699	Gas Production at CBM Wells
321	NLCD Recreational Land	711	Airport Areas
340	*NLCD Land*	801	Port Areas
350	NLCD Water	*805*	*Offshore Shipping Area*
500	*Commercial Land*	*806*	*Offshore Shipping NEI2014 Activity*
505	Industrial Land	*807*	*Navigable Waterway Miles*
506	Education	808	2013 Shipping Density
510	*Commercial plus Industrial*	820	Ports NEI2014 Activity

Code	Surrogate Description	Code	Surrogate Description
535	Residential + Commercial + Industrial + Institutional + Government	850	Golf Courses
560	Hospital (COM6)	860	Mines

For the onroad sector, the on-network (RPD) emissions were spatially allocated differently from other off-network processes (e.g., RPV, RPP). On-network used AADT data and off network used land use surrogates as shown in Table 3-26. Emissions from the extended (i.e., overnight) idling of trucks were assigned to surrogate 205, which is based on locations of overnight truck parking spaces. This surrogate's underlying data were updated for use in the 2016 platforms to include additional data sources and corrections based on comments received. These updates were carried into this platform.

Table 3-26. Off-Network Mobile Source Surrogates

Source type	Source Type name	**Surrogate ID**	**Description**
11	Motorcycle	307	NLCD All Development
21	Passenger Car	307	NLCD All Development
31	Passenger Truck	307	NLCD All Development
32	Light Commercial Truck	308	NLCD Low + Med + High
41	Intercity Bus	258	Intercity Bus Terminals
42	Transit Bus	259	Transit Bus Terminals
43	School Bus	506	Education
51	Refuse Truck	306	NLCD Med + High
52	Single Unit Short-haul Truck	306	NLCD Med + High
53	Single Unit Long-haul Truck	306	NLCD Med + High
54	Motor Home	304	NLCD Open + Low
61	Combination Short-haul Truck	306	NLCD Med + High
62	Combination Long-haul Truck	306	NLCD Med + High

For the oil and gas sources in the np_oilgas sector, the spatial surrogates were updated to those shown in Table 3-27 using 2017 data consistent with what was used to develop the nonpoint oil and gas emissions. The primary activity data source used for the development of the oil and gas spatial surrogates was data from Drilling Info (DI) Desktop's HPDI database (Drilling Info, 2017). This database contains well-level location, production, and exploration statistics at the monthly level. Due to a proprietary agreement with DI Desktop, individual well locations and ancillary production cannot be made publicly available, but aggregated statistics are allowed. These data were supplemented with data from state Oil and Gas Commission (OGC) websites (Alaska, Arizona, Idaho, Illinois, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Nevada, Oregon and Pennsylvania, Tennessee). In cases when the desired surrogate parameter was not available (e.g., feet drilled), data for an alternative surrogate parameter (e.g., number of spudded wells) was downloaded and used. Under that methodology, both completion date and date of first production from HPDI were used to identify wells completed during 2017. In total, over 1 million unique wells were compiled from the above data sources. The wells cover 34 states and over 1,100 counties. (ERG, 2018).

The spatial surrogates, numbered 670 through 699 and also 6831, 6832, and 6833, were originally processed at 4km resolution and without gapfilling. The surrogates were first gapfilled using fallback surrogates. For each surrogate, the last two fallbacks were surrogate 693 (Well Count – All Wells) and

304 (NLCD Open + Low). Where appropriate, other surrogates were also part of the gapfilling procedure. For example, surrogate 670 (Spud Count – CBM Wells) was first gapfilled with 692 (Spud Count – All Wells), and then 693 and finally 304. After gapfilling, surrogates were aggregated to 12km and 36km resolution. All gapfilling and aggregating was performed with the Surrogate Tool.

Table 3-27. Spatial Surrogates for Oil and Gas Sources

Surrogate Code	Surrogate Description
670	Spud Count - CBM Wells
671	Spud Count - Gas Wells
672	Gas Production at Oil Wells
673	Oil Production at CBM Wells
674	Unconventional Well Completion Counts
676	Well Count - All Producing
677	Well Count - All Exploratory
678	Completions at Gas Wells
679	Completions at CBM Wells
681	Spud Count - Oil Wells
683	Produced Water at All Wells
685	Completions at Oil Wells
686	Completions at All Wells
687	Feet Drilled at All Wells
689	Gas Produced – Total
691	Well Counts - CBM Wells
692	Spud Count - All Wells
693	Well Count - All Wells
694	Oil Production at Oil Wells
695	Well Count - Oil Wells
696	Gas Production at Gas Wells
697	Oil Production at Gas Wells
698	Well Count - Gas Wells
699	Gas Production at CBM Wells
6831	Produced water at CBM wells
6832	Produced water at gas wells
6833	Produced water at oil wells

Not all of the available surrogates are used to spatially allocate sources in the modeling platform; that is, some surrogates shown in Table 3-25 were not assigned to any SCCs, although many of the "unused" surrogates are actually used to "gap fill" other surrogates that are used. When the source data for a surrogate has no values for a particular county, gap filling is used to provide values for the surrogate in those counties to ensure that no emissions are dropped when the spatial surrogates are applied to the emission inventories. Table 3-28 shows the CAP emissions (i.e., NH_3, NOx, $PM_{2.5}$, SO_2, and VOC) by sector assigned to each spatial surrogate.

Table 3-28. Selected 2017 CAP emissions by sector for U.S. Surrogates (short tons in 12US1)

Sector	ID	Description	NH_3	NO_X	$PM_{2.5}$	SO_2	VOC
afdust	240	Total Road Miles			309,376		
afdust	304	NLCD Open + Low			842,116		
afdust	306	NLCD Med + High			52,278		
afdust	308	NLCD Low + Med + High			117,313		
afdust	310	NLCD Total Agriculture			791,881		
ag	310	NLCD Total Agriculture	3,457,964				227,853
nonpt	100	Population	34,304	0	0	0	1,181,307
nonpt	150	Residential Heating - Natural Gas	33,550	204,371	4,041	1,365	12,055
nonpt	170	Residential Heating - Distillate Oil	1,531	30,031	3,284	11,510	1,039
nonpt	180	Residential Heating - Coal	1	3	1	3	3
nonpt	190	Residential Heating - LP Gas	98	31,061	163	712	1,181
nonpt	239	Total Road AADT	0	22	541	0	297,798
nonpt	240	Total Road Miles	0	0	0	0	39,013
nonpt	244	All Unrestricted AADT	0	0	0	0	101,255
nonpt	271	NTAD Class 1 2 3 Railroad Density	0	0	0	0	2,203
nonpt	300	NLCD Low Intensity Development	4,823	19,093	94,548	2,882	72,599
nonpt	306	NLCD Med + High	23,713	274,780	246,324	131,747	878,553
nonpt	307	NLCD All Development	109	25,803	110,507	8,260	574,679
nonpt	308	NLCD Low + Med + High	886	156,239	15,825	10,081	65,798
nonpt	310	NLCD Total Agriculture	0	0	38	0	227,051
nonpt	319	NLCD Crop Land	0	0	97	72	299
nonpt	320	NLCD Forest Land	3,953	68	273	0	279
nonpt	505	Industrial Land	0	0	0	0	48
nonpt	535	Residential + Commercial + Industrial + Institutional + Government	0	2	121	0	36
nonpt	650	Refineries and Tank Farms	0	16	0	0	106,401
nonpt	711	Airport Areas	0	0	0	0	596
nonpt	801	Port Areas	0	0	0	0	6,730
nonroad	261	NTAD Total Railroad Density	3	2,026	212	2	398
nonroad	304	NLCD Open + Low	4	1,763	152	5	2,598
nonroad	305	NLCD Low + Med	94	15,378	3,843	116	108,457
nonroad	306	NLCD Med + High	315	173,548	11,084	399	90,482
nonroad	307	NLCD All Development	100	30,701	15,370	117	170,196
nonroad	308	NLCD Low + Med + High	532	315,346	26,575	525	50,340
nonroad	309	NLCD Open + Low + Med	120	21,204	1,253	149	45,270
nonroad	310	NLCD Total Agriculture	419	353,338	26,071	444	37,536
nonroad	320	NLCD Forest Land	15	4,767	610	14	3,824
nonroad	321	NLCD Recreational Land	83	12,197	6,142	94	230,274
nonroad	350	NLCD Water	189	115,331	5,398	221	320,701
nonroad	850	Golf Courses	13	2,039	118	16	5,617
nonroad	860	Mines	2	2,579	262	3	493
np_oilgas	670	Spud Count - CBM Wells	0	0	0	0	152

Sector	ID	Description	NH_3	NO_X	$PM_{2.5}$	SO_2	VOC
np_oilgas	671	Spud Count - Gas Wells	0	0	0	0	4,761
np_oilgas	672	Gas Production - Oil Wells	0	511	0	205	60,626
np_oilgas	674	Unconventional Well Completion Counts	3	20,367	485	202	2,260
np_oilgas	678	Completions at Gas Wells	0	7,843	192	3,578	19,743
np_oilgas	679	Completions at CBM Wells	0	3	0	105	484
np_oilgas	681	Spud Count - Oil Wells	0	0	0	0	28,490
np_oilgas	683	Produced Water at All Wells	0	22	0	0	868
np_oilgas	685	Completions at Oil Wells	0	825	0	426	38,265
np_oilgas	687	Feet Drilled at All Wells	4	37,669	1,172	176	3,639
np_oilgas	691	Well Counts - CBM Wells	0	19,926	289	7	15,937
np_oilgas	692	Spud Count - All Wells	0	365	12	42	34
np_oilgas	693	Well Count - All Wells	0	0	0	0	2
np_oilgas	694	Oil Production at Oil Wells	0	4,193	0	6,104	793,175
np_oilgas	695	Well Count - Oil Wells	0	141,275	3,476	19,198	484,384
np_oilgas	696	Gas Production at Gas Wells	0	40,880	278	4,251	259,234
np_oilgas	697	Oil Production - Gas Wells	0	858	0	0	80,817
np_oilgas	698	Well Count - Gas Wells	7	324,370	4,475	143	516,440
np_oilgas	699	Gas Production at CBM Wells	0	33	5	0	6,090
np_oilgas	6831	Produced Water at CBM Wells	0	0	0	0	79,531
np_oilgas	6832	Produced Water at Gas Wells	0	0	0	0	17,360
np_oilgas	6833	Produced Water at Oil Wells	0	0	0	0	846
onroad	205	Extended Idle Locations	251	89,719	763	41	15,078
onroad	239	Total Road AADT					5,774
onroad	242	All Restricted AADT	34,371	1,093,396	35,386	8,124	187,892
onroad	244	All Unrestricted AADT	64,963	1,701,659	65,959	16,291	460,414
onroad	258	Intercity Bus Terminals		195	2	0	67
onroad	259	Transit Bus Terminals		77	5	0	195
onroad	304	NLCD Open + Low		1,149	38	1	5,411
onroad	306	NLCD Med + High		13,678	267	17	15,343
onroad	307	NLCD All Development		525,284	9,761	817	1,038,858
onroad	308	NLCD Low + Med + High		36,174	633	51	56,651
onroad	506	Education		599	14	1	583
rail	261	NTAD Total Railroad Density	14	34,523	1,022	30	1,755
rail	271	NTAD Class 1 2 3 Railroad Density	328	522,862	14,493	652	23,949
rwc	300	NLCD Low Intensity Development	16,409	34,095	299,280	7,989	323,683

3.4.2 Allocation method for airport-related sources in the U.S.

There are numerous airport-related emission sources in the NEI, such as aircraft, airport ground support equipment, and jet refueling. The modeling platform includes the aircraft and airport ground support equipment emissions as point sources. For the modeling platform, the EPA used the SMOKE “area-to-point” approach for only jet refueling in the nonpt sector. The following SCCs use this approach:

2501080050 and 2501080100 (petroleum storage at airports), and 2810040000 (aircraft/rocket engine firing and testing). The ARTOPNT approach is described in detail in the 2002 platform documentation: http://www3.epa.gov/scram001/reports/Emissions%20TSD%20Vol1_02-28-08.pdf. The ARTOPNT file that lists the nonpoint sources to locate using point data were unchanged from the 2005-based platform.

3.4.3 Surrogates for Canada and Mexico emission inventories

The surrogates for Canada to spatially allocate the Canadian emissions are based on the 2015 Canadian inventories and associated data. The spatial surrogate data came from ECCC, along with cross references. The shapefiles they provided were used in the Surrogate Tool (previously referenced) to create spatial surrogates. The Canadian surrogates used for this platform are listed in Table 3-15. The population surrogate was updated for Mexico for the 2014v7.1 platform. Surrogate code 11, which uses 2015 population data at 1 km resolution, replaces the previous population surrogate code 10. The other surrogates for Mexico are circa 1999 and 2000 and were based on data obtained from the Sistema Municpal de Bases de Datos (SIMBAD) de INEGI and the Bases de datos del Censo Economico 1999. Most of the CAPs allocated to the Mexico and Canada surrogates are shown in Table 3-30.

Table 3-29. Canadian Spatial Surrogates

Code	Canadian Surrogate Description	Code	Description
100	Population	921	Commercial Fuel Combustion
101	total dwelling	923	TOTAL INSTITUTIONAL AND GOVERNEMNT
104	capped total dwelling	924	Primary Industry
106	ALL_INDUST	925	Manufacturing and Assembly
113	Forestry and logging	926	Distribution and Retail (no petroleum)
200	Urban Primary Road Miles	927	Commercial Services
210	Rural Primary Road Miles	932	CANRAIL
211	Oil and Gas Extraction	940	PAVED ROADS NEW
212	Mining except oil and gas	946	Construction and mining
220	Urban Secondary Road Miles	948	Forest
221	Total Mining	951	Wood Consumption Percentage
222	Utilities	955	UNPAVED_ROADS_AND_TRAILS
230	Rural Secondary Road Miles	960	TOTBEEF
233	Total Land Development	970	TOTPOUL
240	capped population	980	TOTSWIN
308	Food manufacturing	990	TOTFERT
321	Wood product manufacturing	996	urban_area
323	Printing and related support activities	1251	OFFR_TOTFERT
324	Petroleum and coal products manufacturing	1252	OFFR_MINES
326	Plastics and rubber products manufacturing	1253	OFFR Other Construction not Urban
327	Non-metallic mineral product manufacturing	1254	OFFR Commercial Services
331	Primary Metal Manufacturing	1255	OFFR Oil Sands Mines
350	Water	1256	OFFR Wood industries CANVEC

Code	Canadian Surrogate Description	Code	Description
412	Petroleum product wholesaler-distributors	1257	OFFR UNPAVED ROADS RURAL
448	clothing and clothing accessories stores	1258	OFFR_Utilities
482	Rail transportation	1259	OFFR total dwelling
562	Waste management and remediation services	1260	OFFR_water
901	AIRPORT	1261	OFFR_ALL_INDUST
902	Military LTO	1262	OFFR Oil and Gas Extraction
903	Commercial LTO	1263	OFFR_ALLROADS
904	General Aviation LTO	1265	OFFR_CANRAIL
945	Commercial Marine Vessels	9450	Commercial Marine Vessel Ports

Table 3-30. CAPs Allocated to Mexican and Canadian Spatial Surrogates (short tons in 12US2)

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	$PM_{2.5}$	SO_2	VOC
11	MEX 2015 Population	0	75,091	454	151	204,890
14	MEX Residential Heating - Wood	0	1,942	5,445	162	14,562
16	MEX Residential Heating - Distillate Oil	1	25	0	0	1
22	MEX Total Road Miles	2,493	316,652	10,056	5,277	63,239
24	MEX Total Railroads Miles	0	20,893	467	183	816
26	MEX Total Agriculture	95,034	17,101	13,147	412	3,565
32	MEX Commercial Land	0	68	1,478	0	24,996
34	MEX Industrial Land	79	2,016	1,173	5	31,706
36	MEX Commercial plus Industrial Land	4	6,464	327	12	92,441
40	MEX Residential (RES1-4)+Comercial+Industrial+Institutional +Government	0	15	66	1	18,980
42	MEX Personal Repair (COM3)	0	0	0	0	4,576
44	MEX Airports Area	0	3,445	51	224	1,343
48	MEX Brick Kilns	0	192	3,849	349	94
50	MEX Mobile sources - Border Crossing	3	71	2	0	57
100	CAN Population	611	42	515	12	175
101	CAN total dwelling	0	0	0	0	115,985
104	CAN capped total dwelling	264	26,357	1,986	148	1,394
106	CAN ALL_INDUST	0	0	2,824	0	0
113	CAN Forestry and logging	81	962	5,294	20	2,715
200	CAN Urban Primary Road Miles	1,162	49,767	1,767	219	5,210
210	CAN Rural Primary Road Miles	457	28,045	964	88	2,223
211	CAN Oil and Gas Extraction	0	30	26	8	366

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	$PM_{2.5}$	SO_2	VOC
212	CAN Mining except oil and gas	0	0	2,369	0	0
220	CAN Urban Secondary Road Miles	2,151	77,473	3,543	455	13,514
221	CAN Total Mining	0	0	32,447	0	0
222	CAN Utilities	27	1,419	12,364	346	16
230	CAN Rural Secondary Road Miles	1,236	54,510	1,953	243	6,198
240	CAN capped population	28	34,842	838	50	64,072
308	CAN Food manufacturing	0	0	15,711	0	9,438
321	CAN Wood product manufacturing	493	3,074	1,142	148	10,455
323	CAN Printing and related support activities	0	0	0	0	10,199
324	CAN Petroleum and coal products manufacturing	0	615	779	298	2,906
326	CAN Plastics and rubber products manufacturing	0	0	0	0	15,320
327	CAN Non-metallic mineral product manufacturing	0	0	5,302	0	0
331	CAN Primary Metal Manufacturing	0	145	5,442	29	72
412	CAN Petroleum product wholesaler-distributors	0	0	0	0	35,673
448	CAN clothing and clothing accessories stores	0	0	0	0	117
482	CAN Rail transportation	1	2,438	52	7	148
562	CAN Waste management and remediation services	224	1,622	1,896	2,411	10,118
901	CAN AIRPORT	0	75	7	0	7
921	CAN Commercial Fuel Combustion	157	16,140	1,674	1,053	728
923	CAN TOTAL INSTITUTIONAL AND GOVERNEMNT	0	0	0	0	11,402
924	CAN Primary Industry	0	0	0	0	28,417
925	CAN Manufacturing and Assembly	0	0	0	0	57,090
926	CAN Distribution and Retail (no petroleum)	0	0	0	0	5,704
927	CAN Commercial Services	0	0	0	0	24,917
932	CAN CANRAIL	33	62,174	1,436	260	2,972
940	CAN PAVED ROADS NEW	0	0	141,178	0	0
946	CAN Construction and mining	0	0	0	0	2,676
951	CAN Wood Consumption Percentage	1,459	16,211	133,259	2,316	188,165
955	CAN UNPAVED_ROADS_AND_TRAILS	0	0	212,342	0	0
960	CAN TOTBEEF	0	0	792	0	0
970	CAN TOTPOUL	0	0	156	0	0
980	CAN TOTSWIN	0	0	682	0	0
990	CAN TOTFERT	33	3,199	226	6,464	120
996	CAN urban_area	0	0	326	0	0

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	$PM_{2.5}$	SO_2	VOC
1251	CAN OFFR_TOTFERT	48	42,015	3,041	34	4,082
1252	CAN OFFR_MINES	1	627	46	1	95
1253	CAN OFFR Other Construction not Urban	44	32,470	3,616	31	7,558
1254	CAN OFFR Commercial Services	32	13,624	1,990	27	33,516
1255	OFFR Oil Sands Mines	0	0	0	0	0
1256	CAN OFFR Wood industries CANVEC	6	3,648	293	4	895
1257	CAN OFFR UNPAVED ROADS RURAL	20	7,359	702	17	28,618
1258	CAN OFFR_Utilities	6	3,876	255	5	833
1259	CAN OFFR total dwelling	13	4,585	582	11	11,645
1260	CAN OFFR_water	3	785	86	4	5,445
1261	CAN OFFR_ALL_INDUST	3	4,823	211	2	898
1262	CAN OFFR Oil and Gas Extraction	0	56	12	0	78
1263	CAN OFFR_ALLROADS	2	1,706	168	2	396
1265	CAN OFFR_CANRAIL	0	69	7	0	12

4 Emission Summaries

Tables 4-1 through 4-3 summarize emissions by sector for the 2017gb case. These summaries are provided at the national level by sector for the contiguous U.S. and for the portions of Canada and Mexico inside the larger 12km domain (12US1) discussed in Section 3.1. Note that totals for the 12US2 domain are not available here, but the sum of the U.S. sectors would be essentially the same and only the Canadian and Mexican emissions would change according to the extent of the grids to the north and south of the continental United States. The afdust sector emissions here represent the emissions *after* application of both the land use (transport fraction) and meteorological adjustments; therefore, this sector is called "afdust_adj" in these summaries. The onroad sector totals are post-SMOKE-MOVES totals, representing air quality model-ready emission totals, and include CARB emissions for California. The cmv sectors include U.S. emissions within state waters only; these extend to roughly 3-5 miles offshore and includes CMV emissions at U.S. ports. "Offshore" represents CMV emissions that are outside of U.S. state waters. Canadian CMV emissions are included in the other sector. The total of all US sectors is listed as "Con U.S. Total."

State totals and other summaries are available in the reports area on the FTP site for the 2017 platform (https://gaftp.epa.gov/Air/emismod/2017/).

Table 4-1. National by-sector CAP emissions for the 2017gb case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,313,419	880,170		
Ag		3,457,964					227,853
airports	479,642	0	128,482	9,725	8,499	16,040	54,104
cmv_c1c2	24,150	85	166,625	4,569	4,428	648	6,596
cmv_c3	14,721	41	116,250	2,325	2,139	4,780	9,100
nonpt	1,928,006	102,968	741,729	573,265	475,768	166,650	3,593,050
nonroad	10,478,152	1,890	1,050,224	102,809	97,089	2,105	1,066,205
np_oilgas	604,340	13	599,138	10,530	10,384	34,438	2,413,140
onroad	19,241,496	99,587	3,461,929	236,730	112,826	25,344	1,786,266
ptagfire	359,379	86,695	15,907	47,295	29,171	6,069	45,292
ptfire	23,817,819	389,528	357,178	2,460,819	2,087,231	186,731	5,555,642
ptegu	608,586	22,741	1,173,262	136,155	111,723	1,396,988	32,003
ptnonipm	1,351,965	60,677	871,085	380,035	242,454	584,625	739,591
pt_oilgas	159,713	2,175	332,011	11,762	11,478	38,812	125,336
rail	109,882	342	557,384	16,021	15,515	682	25,704
rwc	2,160,536	16,409	34,095	300,141	299,280	7,989	323,683
Con. U.S. Total	**61,338,388**	**4,241,116**	**9,605,297**	**10,605,600**	**4,388,157**	**2,471,900**	**16,003,565**
beis	3,852,455		980,479				25,255,118
CONUS + beis	**65,190,843**	**4,241,116**	**10,585,776**	**10,605,600**	**4,388,157**	**2,471,900**	**41,258,684**
Can./Mex./Offshore							
Sector	**CO**	**NH3**	**NOX**	**PM10**	**PM2_5**	**SO2**	**VOC**
Canada othafdust				1,004,479	176,964		
Canada othar	2,707,964	4,785	373,473	309,767	242,457	19,655	827,125
Canada onroad_can	1,602,360	6,667	362,085	25,344	13,290	1,354	129,089
Canada othpt	1,085,244	531,101	639,119	109,295	46,980	981,159	768,720
Canada othptdust				155,197	56,278		
Canada ptfire_othna	5,337,594	109,386	228,651	744,538	628,852	42,216	1,568,403
Canada CMV	11,103	37	96,590	1,716	1,594	2,939	5,410
Mexico othar	115,441	111,699	60,045	104,881	34,686	1,729	361,626
Mexico onroad_mex	1,829,349	2,852	447,216	15,361	10,925	6,441	158,925
Mexico othpt	108,706	1,093	190,439	53,889	37,386	354,772	35,671
Mexico ptfire_othna	545,772	10,555	21,773	72,378	61,857	4,527	155,324
Offshore cmv in Federal waters	33,562	129	296,981	7,243	6,708	28,296	16,345
Offshore cmv outside Federal waters	24,257	457	267,280	25,795	23,738	189,007	11,520
Offshore pt_oilgas	51,866	8	49,959	636	635	462	38,803
Non-U.S. Total	**13,453,218**	**778,770**	**3,033,612**	**2,630,518**	**1,342,350**	**1,632,557**	**4,076,960**

Table 4-2. National by-sector VOC HAP emissions for the 2017gb case, 12US1 grid (tons/yr)

Sector	Acetaldehyde	Benzene	Formaldehyde	Methanol	Naphthalene	Acrolein	1,3-Butadiene
ag	1,583	457	0	16,222	0	0	0
airports	2,076	930	6,008	867	593	1,178	837
cmv_c1c2	64	31	282	0	18	12	7
cmv_c3	89	43	389	0	25	17	9
nonpt	5,043	9,701	5,843	148,098	4,786	222	778
nonroad	10,445	27,383	26,365	1,390	1,796	1,913	4,360
np_oilgas	2,722	26,869	23,413	1,578	104	1,602	337
onroad	20,315	42,821	26,511	3,043	3,545	1,831	6,410
ptegu	293	457	2,493	114	22	267	3
ptagfire	2,766	987	2,984	0	0	0	301
ptfire	184,210	55,154	348,557	333,686	53,919	60,736	34,691
ptnonipm	6,012	3,091	6,528	52,233	1,125	787	611
pt_oilgas	2,503	1,028	12,452	1,748	25	1,851	261
rail	1,863	535	5,306	0	67	380	44
rwc	8,476	15,634	17,190	0	2,393	821	1,981
Con. U.S. Total	**248,462**	**185,122**	**484,322**	**558,981**	**68,417**	**71,616**	**50,631**
beis	403,401	0	550,102	2,026,335	0	0	0
CONUS + beis	**651,862**	**185,122**	**1,034,423**	**2,585,316**	**68,417**	**71,616**	**50,631**
Canada othar	24,392	37,424	19,647	4,567	3,945	0	0
Canada onroad_can	2,286	5,658	3,117	0	43	0	0
Canada othpt	2,475	44,342	4,453	42,303	66	0	0
Canada ptfire_othna	56,327	36,553	164,688	135,852	0	0	0
Canada CMV	53	27	231	0	15	10	5
Mexico othar	3,148	6,218	2,403	6,187	437	0	0
Mexico onroad_mex	685	3,975	1,620	620	238	115	595
Mexico othpt	74	809	2,957	450	12	0	0
Mexico ptfire_othna	9,425	3,415	15,409	9,684	0	0	0
Offshore cmv in Federal waters	160	77	698	0	45	30	17
Offshore cmv outside Federal waters	113	55	492	0	31	21	12
Offshore pt_oilgas	0	0	0	0	0	0	0
Non-U.S. Total	**99,137**	**138,554**	**215,715**	**199,663**	**4,831**	**177**	**629**

Table 4-3. National by-sector Diesel PM and metal emissions for the 2017gb case, 12US1 grid (tons/yr)

Sector	Diesel PM_{10}	Diesel $PM_{2.5}$	Chromium Hex	Arsenic	Cadmium	Nickel	Manganese	Ethylene Oxide
airports	76	74	--	--	--	--	--	--
cmv_c1c2	4,569	4,428	0.00003	0.11	1.05	3.04	0.01	--
cmv_c3	2,325	2,139	0.00002	0.06	0.50	1.47	0.01	--
nonpt	--	--	0.357	5.96	3.77	26.82	15.56	0.95
nonroad	61,662	59,630	0.004	0.87	--	1.12	0.68	--
np_oilgas	--	--	0.00005	0.01	0.07	0.03	0.02	--
onroad	61,942	57,082	0.038	7.36	--	5.80	30.99	--
ptegu	--	--	6.347	7.01	6.19	64.65	127.33	0.004
ptnonipm	1,115	1,002	25.864	28.28	13.92	185.03	640.53	109.46
pt_oilgas	--	--	0.027	0.02	0.33	6.75	3.12	--
rail	16,021	15,515	0.074	15.25	0.03	57.31	32.78	--
rwc	--	--	--	--	0.08	0.07	0.62	--
Con. U.S. Total	**147,709**	**139,869**	**32.71**	**64.94**	**25.95**	**352.10**	**851.64**	**110.42**
Canada CMV	1,476	1,354	0.00001	0.04	0.32	0.93	0.004	--
Offshore CMV ECA	7,243	6,708	0.00005	0.17	1.58	4.61	0.02	--
Offshore CMV non-ECA	25,796	23,739	0.00017	0.61	5.60	16.31	0.08	--

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Appendix A: **CB6 Assignment for New Species**

September 27, 2016

MEMORANDUM

To: Alison Eyth and Madeleine Strum, OAQPS, EPA
From: Ross Beardsley and Greg Yarwood, Ramboll Environ
Subject: Species Mappings for CB6 and CB05 for use with SPECIATE 4.5

Summary

Ramboll Environ (RE) reviewed version 4.5 of the SPECIATE database, and created CB05 and CB6 mechanism species mappings for newly added compounds. In addition, the mapping guidelines for Carbon Bond (CB) mechanisms were expanded to promote consistency in current and future work.

Background

The Environmental Protection Agency's SPECIATE repository contains gas and particulate matter speciation profiles of air pollution sources, which are used in the generation of emissions data for air quality models (AQM) such as CMAQ (http://www.cmascenter.org/cmaq/) and CAMx (http://www.camx.com). However, the condensed chemical mechanisms used within these photochemical models utilize fewer species than SPECIATE to represent gas phase chemistry, and thus the SPECIATE compounds must be assigned to the AQM model species of the condensed mechanisms. A chemical mapping is used to show the representation of organic chemical species by the model compounds of the condensed mechanisms.

This memorandum describes how chemical mappings were developed from SPECIATE 4.5 compounds to model species of the CB mechanism, specifically CB05 (http://www.camx.com/publ/pdfs/CB05_Final_Report_120805.pdf) and CB6 (http://aqrp.ceer.utexas.edu/projectinfoFY12_13/12-012/12-012%20Final%20Report.pdf).

Methods

CB Model Species

Organic gases are mapped to the CB mechanism either as explicitly represented individual compounds (e.g. ALD2 for acetaldehyde), or as a combination of model species that represent common structural groups (e.g. ALDX for other aldehydes, PAR for alkyl groups). Table 1 lists all of the explicit and structural model species in CB05 and CB6 mechanisms, each of which represents a defined number of carbon atoms allowing for carbon to be conserved in all cases. CB6 contains four more explicit model species than CB05 and an additional structural group to represent ketones. The CB05 representation of the five additional CB6 species is provided in the '*Included in CB05*' column of Table 1.

In addition to the explicit and structural species, there are two model species that are used to represent organic gases that are not treated by the CB mechanism:

NVOL – Very low volatility SPECIATE compounds that reside predominantly in the particle phase and should be excluded from the gas phase mechanism. These compounds are mapped by setting NVOL equal to the molecular weight (e.g. decabromodiphenyl oxide is mapped as 959.2 NVOL), which allows for the total mass of all NVOL to be determined.

UNK – Compounds that are unable to be mapped to CB using the available model species. This approach should be avoided unless absolutely necessary, and will lead to a warning message in the speciation tool

Table 1. Model species in the CB05 and CB6 chemical mechanisms.

Model Species Name	Description	Number of Carbons	Included in CB05 (structural mapping)	Included in CB6
Explicit model species				
ACET	Acetone (propanone)	3	No (3 PAR)	Yes
ALD2	Acetaldehyde (ethanal)	2	Yes	Yes
BENZ	Benzene	6	No (1 PAR, 5 UNR)	Yes
CH4	Methane	1	Yes	Yes
ETH	Ethene (ethylene)	2	Yes	Yes
ETHA	Ethane	2	Yes	Yes
ETHY	Ethyne (acetylene)	2	No (1 PAR, 1 UNR)	Yes
ETOH	Ethanol	2	Yes	Yes
FORM	Formaldehyde (methanal)	1	Yes	Yes
ISOP	Isoprene (2-methyl-1,3-butadiene)	5	Yes	Yes
MEOH	Methanol	1	Yes	Yes
PRPA	Propane	3	No (1.5 PAR, 1.5 UNR)	Yes
Common Structural groups				
ALDX	Higher aldehyde group (-C-CHO)	2	Yes	Yes
IOLE	Internal olefin group ($(R_1R_2)C=C(R_3R_4)$)	4	Yes	Yes
KET	Ketone group ($(R_1R_2)C=O$)	1	No (1 PAR)	Yes
OLE	Terminal olefin group ($(R_1R_2)C=C$)	2	Yes	Yes
PAR	Paraffinic group (R_1-$C(R_2R_3)$)	1	Yes	Yes
TERP	Monoterpenes	10	Yes	Yes
TOL	Toluene and other monoalkyl aromatics	7	Yes	Yes
UNR	Unreactive carbon groups (e.g., halogenated carbons)	1	Yes	Yes
XYL	Xylene and other polyalkyl aromatics	8	Yes	Yes
Not mapped to CB model species				
NVOL	Very low volatility compounds	*	Yes	Yes
UNK	unknown	*	Yes	Yes

*Each NVOL represents 1 g mol^{-1} and low volatility compounds are assigned to NVOL based on molecular weight. UNK is unmapped and thus does not represent any carbon.

Mapping guidelines for non-explicit organic gases using CB model species

SPECIATE compounds that are not treated explicitly are mapped to CB model species that represent common structural groups. Table 2 lists the carbon number and general mapping guidelines for each of the structure model species.

Table 2. General Guidelines for mapping using CB6 structural model species.

CB6 Species Name	Number of Carbons	Represents
ALDX	2	Aldehyde group. ALDX represents 2 carbons and additional carbons are represented as alkyl groups (mostly PAR), e.g. propionaldehyde is ALDX + PAR
IOLE	4	Internal olefin group. IOLE represents 4 carbons and additional carbons are represented as alkyl groups (mostly PAR), e.g. 2-pentene isomers are IOLE + PAR *Exceptions:* • IOLE with 2 carbon branches on both sides of the double bond are downgraded to OLE
KET	1	Ketone group. KET represents 1 carbon and additional carbons are represented as alkyl groups (mostly PAR), e.g. butanone is 3 PAR + KET
OLE	2	Terminal olefin group. OLE represents 2 carbons and additional carbons are represented as alkyl groups (mostly PAR), e.g. propene is OLE + PAR. Alkyne group, e.g. butyne isomers are OLE + 2 PAR.
PAR	1	Alkanes and alkyl groups. PAR represents 1 carbon, e.g. butane is 4 PAR. See UNR for exceptions.
TERP	10	All monoterpenes are represented as 1 TERP
TOL	7	Toluene and other monoalkyl aromatics. TOL represents 7 carbons and any additional carbons are represented as alkyl groups (mostly PAR), e.g. ethylbenzene is TOL + PAR. Cresols are represented as TOL and PAR. Styrenes are represented using TOL, OLE and PAR.
UNR	1	Unreactive carbons are 1 UNR such as quaternary alkyl groups (e.g., neo-pentane is 4 PAR + UNR), carboxylic acid groups (e.g., acetic acid is PAR + UNR), ester groups (e.g., methyl acetate is 2 PAR + UNR), halogenated carbons (e.g., trichloroethane isomers are 2 UNR), carbons of nitrile groups (-C≡N)
XYL	8	Xylene isomers and other polyalkyl aromatics. XYL represents 8 carbons and any additional carbons are represented as alkyl groups (mostly PAR), e.g. trimethylbenzene isomers are XYL + PAR

Some compounds that are multifunctional and/or include hetero-atoms lack obvious CB mappings. We developed guidelines for some of these compound classes to promote consistent representation in this work and future revisions. Approaches for several compound classes are explained in Table 3. We developed guidelines as needed to address newly added species in SPECIATE 4.5 but did not systematically review existing mappings for "difficult to assign" compounds that could benefit from developing a guideline.

Table 3. Mapping guidelines for some difficult to map compound classes and structural groups

Compound Class/Structural group	CB model species representation
Chlorobenzenes and other halogenated benzenes	Guideline: • 3 or less halogens – 1 PAR, 5 UNR • 4 or more halogens – 6 UNR Examples: • 1,3,5-Chlorobenzene – 1 PAR, 5 UNR • Tetrachlorobenzenes – 6 UNR
Cyclodienes	Guideline: • 1 IOLE with additional carbons represented as alkyl groups (generally PAR) Examples: • Methylcyclopentadiene – 1 IOLE, 2 PAR • Methylcyclohexadiene – 1 IOLE, 3 PAR
Furans/Pyrroles	Guideline: • 2 OLE with additional carbons represented as alkyl groups (generally PAR) Examples: • 2-Butylfuran – 2 OLE, 4 PAR • 2-Pentylfuran – 2 OLE, 5 PAR • Pyrrole – 2 OLE • 1-Methylpyrrole – 2 OLE, 1 PAR
Heterocyclic aromatic compounds containing 2 non-carbon atoms	Guideline: • 1 OLE with remaining carbons represented as alkyl groups (generally PAR) Examples: • Ethylpyrazine – 1 OLE, 4 PAR • 1-methylpyrazole – 1 OLE, 2 PAR • 4,5-Dimethyloxazole – 1 OLE, 3 PAR
Triple bond(s)	Guideline: • Triple bonds are treated as PAR unless they are the only reactive functional group. If a compound contains more than one triple bond and no other reactive functional groups, then one of the triple bonds is treated as OLE with additional carbons treated as alkyl groups. Examples: • 1-Penten-3-yne – 1 OLE, 3 PAR • 1,5-Hexadien-3-yne – 2 OLE, 2 PAR • 1,6-Heptadiyne – 1 OLE, 5 PAR

These guidelines were used to map the new species from SPEICATE4.5, and also to revise some previously mapped compounds. Overall, a total of 175 new species from SPECIATEv4.5 were mapped and 7 previously mapped species were revised based on the new guidelines.

Recommendation

1. Complete a systematic review of the mapping of all species to ensure conformity with current mapping guidelines. The assignments of existing compounds that are similar to new species were reviewed and revised to promote consistency in mapping approaches, but the majority of existing species mappings were not reviewed as it was outside the scope of this work.
2. Develop a methodology for classifying and tracking larger organic compounds based on their volatility (semi, intermediate, or low volatility) to improve support for secondary organic aerosol (SOA) modeling using the volatility basis set (VBS) SOA model, which is available in both CMAQ and CAMx. A preliminary investigation of the possibility of doing so has been performed, and is discussed in a separate memorandum.

Appendix B: Profiles (other than onroad) that are new or revised in SPECIATE versions 4.5 and later that were used in the 2016 platforms

Table B-1 Profiles first used in 2016beta, 2016v1, and 2016v2 platforms

Sector	Pollutant	Profile code	Profile description	SPECIATE version
np_oilgas, pt_oilgas	VOC	CMU01	Oil and Gas - Produced Gas Composition from Gas Wells - Central Montana Uplift - Montana	5.1
np_oilgas, pt_oilgas	VOC	WIL01	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin North Dakota	5.1
np_oilgas, pt_oilgas	VOC	WIL02	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin Montana	5.1
np_oilgas, pt_oilgas	VOC	WIL03	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin North Dakota	5.1
np_oilgas, pt_oilgas	VOC	WIL04	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin Montana	5.1
cmv_c1c2, cmv_c3	VOC	95331NEIHP	Marine Vessel - 95331 blend with CMV HAP	5.1

Table B-2 Profiles first used in 2016 alpha platform

Sector	Pollutant	Profile code	Profile description	SPECIATE version	Comment
nonpt	VOC	G95223TOG	Poultry Production - Average of Production Cycle with gapfilled methane and ethane	5.0	Replacement for v4.5 profile 95223; Used 70% methane, 20% ethane, and the 10% remaining VOC is from profile 95223
Nonpt, ptnonipm	VOC	G95240TOG	Beef Cattle Farm and Animal Waste with gapfilled methane and ethane	5.0	Replacement for v4.5 profile 95240. Used 70% methane, 20% ethane; the 10% remaining VOC is from profile 95240.
nonpt	VOC	G95241TOG	Swine Farm and Animal Waste	5.0	Replacement for v4.5 profile 95241. Used 70% methane, 20% ethane; the 10% remaining VOC is from profile 95241
nonpt, ptnonipm, pt_oilgas, ptegu	PM2.5	95475	Composite -Refinery Fuel Gas and Natural Gas Combustion	5.0	Composite of AE6-ready versions of SPECIATE4.5 profiles 95125, 95126, and 95127
nonroad	VOC	95328	Spark-Ignition Exhaust Emissions from 2-stroke off-road engines - E10 ethanol gasoline	4.5	
nonroad	VOC	95330	Spark-Ignition Exhaust Emissions from 4-stroke off-road engines - E10 ethanol gasoline	4.5	

Sector	Pollutant	Profile code	Profile description	SPECIATE version	Comment
nonroad	VOC	95331	Diesel Exhaust Emissions from Pre-Tier 1 Off-road Engines	4.5	
nonroad	VOC	95332	Diesel Exhaust Emissions from Tier 1 Off-road Engines	4.5	
nonroad	VOC	95333	Diesel Exhaust Emissions from Tier 2 Off-road Engines	4.5	
np_oilgas	VOC	95087a	Oil and Gas - Composite - Oil Field - Oil Tank Battery Vent Gas	4.5	
np_oilgas	VOC	95109a	Oil and Gas - Composite - Oil Field - Condensate Tank Battery Vent Gas	4.5	
np_oilgas	VOC	95398	Composite Profile - Oil and Natural Gas Production - Condensate Tanks	4.5	
np_oilgas	VOC	95403	Composite Profile - Gas Wells	4.5	
np_oilgas	VOC	95417	Oil and Gas Production - Composite Profile - Untreated Natural Gas, Uinta Basin	4.5	
np_oilgas	VOC	95418	Oil and Gas Production - Composite Profile - Condensate Tank Vent Gas, Uinta Basin	4.5	
np_oilgas	VOC	95419	Oil and Gas Production - Composite Profile - Oil Tank Vent Gas, Uinta Basin	4.5	
np_oilgas	VOC	95420	Oil and Gas Production - Composite Profile - Glycol Dehydrator, Uinta Basin	4.5	
np_oilgas	VOC	DJVNT_R	Oil and Gas -Denver-Julesburg Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
np_oilgas	VOC	FLR99	Natural Gas Flare Profile with DRE >98%	4.5	
np_oilgas	VOC	PNC01_R	Oil and Gas -Piceance Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
np_oilgas	VOC	PNC02_R	Oil and Gas -Piceance Basin Produced Gas Composition from Oil Wells	4.5	
np_oilgas	VOC	PNC03_R	Oil and Gas -Piceance Basin Flash Gas Composition for Condensate Tank	4.5	
np_oilgas	VOC	PNCDH	Oil and Gas Production - Composite Profile - Glycol Dehydrator, Piceance Basin	4.5	
np_oilgas	VOC	PRBCB_R	Oil and Gas -Powder River Basin Produced Gas Composition from CBM Wells	4.5	
np_oilgas	VOC	PRBCO_R	Oil and Gas -Powder River Basin Produced Gas Composition from Non-CBM Wells	4.5	
np_oilgas	VOC	PRM01_R	Oil and Gas -Permian Basin Produced Gas Composition for Non-CBM Wells	4.5	
np_oilgas	VOC	SSJCB_R	Oil and Gas -South San Juan Basin Produced Gas Composition from CBM Wells	4.5	
np_oilgas	VOC	SSJCO_R	Oil and Gas -South San Juan Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
np_oilgas	VOC	SWFLA_R	Oil and Gas -SW Wyoming Basin Flash Gas Composition for Condensate Tanks	4.5	
np_oilgas	VOC	SWVNT_R	Oil and Gas -SW Wyoming Basin Produced Gas Composition from Non-CBM Wells	4.5	
np_oilgas	VOC	UNT01_R	Oil and Gas -Uinta Basin Produced Gas Composition from CBM Wells	4.5	

Sector	Pollutant	Profile code	Profile description	SPECIATE version	Comment
np_oilgas	VOC	WRBCO_R	Oil and Gas -Wind River Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas	VOC	95325	Chemical Manufacturing Industry Wide Composite	4.5	
pt_oilgas	VOC	95326	Pulp and Paper Industry Wide Composite	4.5	
pt_oilgas, ptnonipm	VOC	95399	Composite Profile - Oil Field - Wells	4.5	
pt_oilgas	VOC	95403	Composite Profile - Gas Wells	4.5	
pt_oilgas	VOC	95417	Oil and Gas Production - Composite Profile - Untreated Natural Gas, Uinta Basin	4.5	
pt_oilgas	VOC	DJVNT_R	Oil and Gas -Denver-Julesburg Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas, ptnonipm	VOC	FLR99	Natural Gas Flare Profile with DRE >98%	4.5	
pt_oilgas	VOC	PNC01_R	Oil and Gas -Piceance Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas	VOC	PNC02_R	Oil and Gas -Piceance Basin Produced Gas Composition from Oil Wells	4.5	
pt_oilgas	VOC	PNCDH	Oil and Gas Production - Composite Profile - Glycol Dehydrator, Piceance Basin	4.5	
pt_oilgas, ptnonipm	VOC	PRBCO_R	Oil and Gas -Powder River Basin Produced Gas Composition from Non-CBM Wells	4.5	
pt_oilgas, ptnonipm	VOC	PRM01_R	Oil and Gas -Permian Basin Produced Gas Composition for Non-CBM Wells	4.5	
pt_oilgas, ptnonipm	VOC	SSJCO_R	Oil and Gas -South San Juan Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas, ptnonipm	VOC	SWVNT_R	Oil and Gas -SW Wyoming Basin Produced Gas Composition from Non-CBM Wells	4.5	
ptfire	VOC	95421	Composite Profile - Prescribed fire southeast conifer forest	4.5	
ptfire	VOC	95422	Composite Profile - Prescribed fire southwest conifer forest	4.5	
ptfire	VOC	95423	Composite Profile - Prescribed fire northwest conifer forest	4.5	
ptfire	VOC	95424	Composite Profile - Wildfire northwest conifer forest	4.5	
ptfire	VOC	95425	Composite Profile - Wildfire boreal forest	4.5	
ptnonipm	VOC	95325	Chemical Manufacturing Industry Wide Composite	4.5	
ptnonipm	VOC	95326	Pulp and Paper Industry Wide Composite	4.5	
onroad	PM2.5	95462	Composite - Brake Wear	4.5	Used in SMOKE-MOVES
onroad	PM2.5	95460	Composite - Tire Dust	4.5	Used in SMOKE-MOVES

Appendix C: Mapping of Fuel Distribution SCCs to BTP, BPS and RBT

The table below provides a crosswalk between fuel distribution SCCs and classification type for portable fuel containers (PFC), fuel distribution operations associated with the bulk-plant-to-pump (BTP), refinery to bulk terminal (RBT) and bulk plant storage (BPS).

SCC	Type	Description
40301001	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 13: Breathing Loss (67000 Bbl. Tank Size)
40301002	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 10: Breathing Loss (67000 Bbl. Tank Size)
40301003	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 7: Breathing Loss (67000 Bbl. Tank Size)
40301004	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 13: Breathing Loss (250000 Bbl. Tank Size)
40301006	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 7: Breathing Loss (250000 Bbl. Tank Size)
40301007	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 13: Working Loss (Tank Diameter Independent)
40301101	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 13: Standing Loss (67000 Bbl. Tank Size)
40301102	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 10: Standing Loss (67000 Bbl. Tank Size)
40301103	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 7: Standing Loss (67000 Bbl. Tank Size)
40301105	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 10: Standing Loss (250000 Bbl. Tank Size)
40301151	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline: Standing Loss - Internal
40301202	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Variable Vapor Space; Gasoline RVP 10: Filling Loss
40301203	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Variable Vapor Space; Gasoline RVP 7: Filling Loss
40400101	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400102	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400103	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400104	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank
40400105	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank
40400106	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Breathing Loss (250000 Bbl Capacity) - Fixed Roof Tank
40400107	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Working Loss (Diam. Independent) - Fixed Roof Tank
40400108	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Working Loss (Diameter Independent) - Fixed Roof Tank
40400109	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Working Loss (Diameter Independent) - Fixed Roof Tank
40400110	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank

SCC	Type	Description
40400111	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank
40400112	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss (67000 Bbl Capacity)- Floating Roof Tank
40400113	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank
40400114	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank
40400115	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank
40400116	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk
40400117	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss (250000 Bbl Cap.) - Float Rf Tnk
40400118	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400119	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400120	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400130	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - External Floating Roof w/ Primary Seal
40400131	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400132	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400133	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - External Floating Roof w/ Primary Seal
40400140	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - Ext. Float Roof Tank w/ Secondy Seal
40400141	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400142	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400143	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400148	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss - Ext. Float Roof (Pri/Sec Seal)
40400149	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: External Floating Roof (Primary/Secondary Seal)
40400150	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Miscellaneous Losses/Leaks: Loading Racks
40400151	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Valves, Flanges, and Pumps
40400152	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Vapor Collection Losses
40400153	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Vapor Control Unit Losses
40400160	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - Internal Floating Roof w/ Primary Seal
40400161	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Primary Seal
40400162	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Primary Seal

SCC	Type	Description
40400163	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - Internal Floating Roof w/ Primary Seal
40400170	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400171	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400172	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400173	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400178	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss - Int. Float Roof (Pri/Sec Seal)
40400179	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Internal Floating Roof (Primary/Secondary Seal)
40400199	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals;
40400201	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400202	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400203	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400204	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400205	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400206	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400207	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss (67000 Bbl Cap.) - Floating Roof Tank
40400208	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss (67000 Bbl Cap.) - Floating Roof Tank
40400210	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk
40400211	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400212	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400213	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space

SCC	Type	Description
40400230	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - External Floating Roof w/ Primary Seal
40400231	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400232	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400233	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Standing Loss - External Floating Roof w/ Primary Seal
40400240	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400241	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400248	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10/13/7: Withdrawal Loss - Ext. Float Roof (Pri/Sec Seal)
40400249	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: External Floating Roof (Primary/Secondary Seal)
40400250	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Loading Racks
40400251	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Valves, Flanges, and Pumps
40400252	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Miscellaneous Losses/Leaks: Vapor Collection Losses
40400253	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Miscellaneous Losses/Leaks: Vapor Control Unit Losses
40400260	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - Internal Floating Roof w/ Primary Seal
40400261	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Primary Seal
40400262	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Primary Seal
40400263	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Standing Loss - Internal Floating Roof w/ Primary Seal
40400270	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400271	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400272	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Secondary Seal

SCC	Type	Description
40400273	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400278	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10/13/7: Withdrawal Loss - Int. Float Roof (Pri/Sec Seal)
40400279	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Internal Floating Roof (Primary/Secondary Seal)
40400401	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 13: Breathing Loss
40400402	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 13: Working Loss
40400403	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 10: Breathing Loss
40400404	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 10: Working Loss
40400405	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 7: Breathing Loss
40400406	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 7: Working Loss
40600101	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Splash Loading
40600126	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading
40600131	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading (Normal Service)
40600136	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Splash Loading (Normal Service)
40600141	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading (Balanced Service)
40600144	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Splash Loading (Balanced Service)
40600147	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading (Clean Tanks)
40600162	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Loaded with Fuel (Transit Losses)
40600163	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Return with Vapor (Transit Losses)

SCC	Type	Description
40600199	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Not Classified
40600231	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers: Cleaned and Vapor Free Tanks
40600232	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers
40600233	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Barges: Cleaned and Vapor Free Tanks
40600234	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers: Ballasted Tank
40600235	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Ocean Barges Loading - Ballasted Tank
40600236	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers: Uncleaned Tanks
40600237	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Ocean Barges Loading - Uncleaned Tanks
40600238	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Barges: Uncleaned Tanks
40600239	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Tankers: Ballasted Tank
40600240	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Barges: Average Tank Condition
40600241	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Tanker Ballasting
40600299	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Not Classified
40600301	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Splash Filling
40600302	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Submerged Filling w/o Controls
40600305	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Unloading
40600306	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Balanced Submerged Filling
40600307	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Underground Tank Breathing and Emptying
40600399	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Not Classified **
40600401	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Filling Vehicle Gas Tanks - Stage II; Vapor Loss w/o Controls
40600501	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pipeline Leaks

SCC	Type	Description
40600502	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pipeline Venting
40600503	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pump Station
40600504	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pump Station Leaks
40600602	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage II; Liquid Spill Loss w/o Controls
40600701	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Splash Filling
40600702	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Submerged Filling w/o Controls
40600706	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Balanced Submerged Filling
40600707	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Underground Tank Breathing and Emptying
40688801	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Fugitive Emissions; Specify in Comments Field
2501050120	RBT	Storage and Transport; Petroleum and Petroleum Product Storage; Bulk Terminals: All Evaporative Losses; Gasoline
2501055120	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Bulk Plants: All Evaporative Losses; Gasoline
2501060050	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Total
2501060051	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Submerged Filling
2501060052	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Splash Filling
2501060053	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Balanced Submerged Filling
2501060200	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Underground Tank: Total
2501060201	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Underground Tank: Breathing and Emptying
2501995000	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; All Storage Types: Working Loss; Total: All Products
2505000120	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; All Transport Types; Gasoline
2505020120	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; Marine Vessel; Gasoline

SCC	Type	Description
2505020121	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; Marine Vessel; Gasoline - Barge
2505030120	BTP/BPS	Storage and Transport; Petroleum and Petroleum Product Transport; Truck; Gasoline
2505040120	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; Pipeline; Gasoline
2660000000	BTP/BPS	Waste Disposal, Treatment, and Recovery; Leaking Underground Storage Tanks; Leaking Underground Storage Tanks; Total: All Storage Types

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