October 18, 2019

SPECIFICATION SHEET: MOBILE NONROAD

Description: Mobile nonroad equipment emissions were developed with the MOVES2014b model, for simulating 2016 and future year U.S. air quality.

1. EXECUTIVE SUMMARY

The mobile nonroad emissions inventory was generated using the Motor Vehicle Emissions Simulator (MOVES) 2014b model with some state-supplied inputs, except in California where inventories are provided by the California Air Resources Board (CARB) and in Texas, where inventories are provided by the Texas Commission on Environmental Quality (TCEQ). CARB and TCEQ both provided nonroad emissions for their states for 2016, 2023, and 2028. For the rest of the country, monthly MOVES2014b output inventories were used after a limited amount of post-processing. Speciation profile assignments for VOC and PM2.5 are internal to MOVES.

Future year projections are based on separate runs of the MOVES model and separate CARB and TCEQ inventories. Base and future year inventories were processed with the Sparse Matrix Operating Kernel Emissions (SMOKE) modeling system version 4.6. SMOKE creates emissions in a format that can be input into air quality models. National and state-level emission summaries for key pollutants are provided.

2. INTRODUCTION

This document details the approach and data sources to be used for developing 2016 emissions for the mobile nonroad equipment sector, which 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 the MOVES2014b model[1], which incorporates the NONROAD2008 model. MOVES2014b replaced MOVES2014a in August 2018, and incorporates updated nonroad engine population growth rates, nonroad Tier 4 engine emission rates, and sulfur levels of nonroad diesel fuels. MOVES2014b provides a complete set of hazardous air pollutants (HAPs) and incorporates updated nonroad emission factors for HAPs. MOVES2014b was used for all states other than California and Texas, which developed their own emissions using their own tools. VOC and PM speciation profile assignments are determined by MOVES and applied by SMOKE.

The 2016 alpha platform used a nonroad inventory created with MOVES2014a, while the 2016 beta platform used MOVES2014b without any state-supplied inputs. As described in Section 3 below, version 1 (v1) of the 2016 platform used MOVES2014b with state-supplied inputs, except for in Texas and California. In addition, per the direction of the Nonroad Collaborative Work Group[2], national updates were made to the MOVES2014b defaults for allocating national populations of Agricultural and Construction equipment to state and county levels.

3. INVENTORY DEVELOPMENT METHODS

Emissions Outside of California and Texas

The MOVES2014b model is used to create the nonroad emissions inventories for modeling years 2016, 2023, and 2028. 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 used for speciation.

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[1] https://www.epa.gov/moves
[2] http://views.cira.colostate.edu/wiki/wiki/9179

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. One of the speciation profile codes is '95335a' (lowercase 'a'); the corresponding inventory pollutant is NONHAPTOG95335A (uppercase 'A') because SMOKE does not support inventory pollutant names with lowercase letters. Since speciation profiles are applied by SCC and pollutant, no changes to SMOKE were needed to use the inventory file with this profile information. This approach was not used for California or Texas, because the datasets in those states included VOC.

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 coarse particulate matter (PMC) within SMOKE, and to help create emissions summaries, an additional pollutant representing total $PM_{2.5}$ called PM25TOTAL was added to the inventory. As with VOC / TOG, this approach is not used for California or Texas.

MOVES2014b 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.

- 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.

- 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.

- California and Texas emissions from MOVES were deleted and replaced with the CARB- and TCEQ-supplied emissions, respectively.

- Emissions for airport ground support vehicles (SCCs ending in -8005), and oil field equipment (SCCs ending in -10010), were removed from the mobile nonroad inventory, to prevent a double count with the ptnonipm and np_oilgas sectors, respectively.

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 Division of Air Quality (NC DAQ). EPA updated the Construction equipment allocation data for the v1 platform.

NC DAQ 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."[3] 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., NC DAQ 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, NC DAQ relied on 2012 fuel expenditure data from NASS' 2012 Census of Agriculture (note that 2017 data were not yet available at the time of this effort).[4] 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, NC DAQ 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

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

[4] Accessed from https://www.nass.usda.gov/Publications/AgCensus/2012/, November 2018.

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).[5] Because the analyzed surrogates 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, NC DAQ 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, NC DAQ 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, NC DAQ 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 NC DAQ 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.[6]

For the Construction sector, MOVES2014b uses estimates of 2003 total dollar value of construction by county to allocate national Construction equipment populations to the state and local levels.[7] However, the 2016 Nonroad Collaborate 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.

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[5] Other variables analyzed were inventory of tractors and inventory of trucks.

[6] For reference, these allocations were 0.0639 percent for Puerto Rico and 0.0002 percent for the U.S. Virgin Islands.

[7] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1004LDX.pdf

The nonpoint sector of the 2014 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.[8] The 2014 NEI Technical Support Document[9] 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.

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 MOVES2014b base-year (1990) 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 2016v1 changes to the Agricultural and Construction equipment sectors.

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: ftp://newftp.epa.gov/air/emismod/2016/v1/reports/nonroad/.

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[8] https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data
[9] https://www.epa.gov/sites/production/files/2018-07/documents/nei2014v2_tsd_05jul2018.pdf

State-Supplied Data

As shown in Table 1, several state and local agencies provided nonroad inputs for use in the 2016v1 platform. 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 (data specific to calendar years 2014 and 2017 were not used in 2016v1).

Table 1. Submitted nonroad input tables by agency

stateid	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						D	D	D	D	D
9	CONNECTICUT	A										
13	GEORGIA			D					D			
16	IDAHO		C									
17	ILLINOIS						E					
18	INDIANA		C				E					
19	IOWA		C				E					
26	MICHIGAN		C				E					
27	MINNESOTA		C				E					
29	MISSOURI						E					
36	NEW YORK	D	D		D	D	D	D	D			
39	OHIO		C				E					
49	UTAH	B	D		D	D			F			
53	WASHINGTON								D		D	D
55	WISCONSIN						E					

[A] Submitted data with modification: updated the year ID to 2016.

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

[C] NEI 2014v2 data used for 2016v1 platform.

[D] Submitted data.

[E] Spreadsheet "ladco_nei2017_nrmonthallocation.xlsx."

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

Comments Received on the 2016beta Inventory

The 2016 Nonroad Collaborative Work group received a small number of comments on the 2016beta inventory, all of which were addressed and implemented in the 2016v1 nonroad inventory:

- **Georgia Department of Natural Resources:** incorporate updated fuel supply (*nrfuelsupply* table) for 45 Georgia counties, to reflect the removal of summer Reid Vapor Pressure restrictions in 2016; 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 MOVES2014b nonroad emissions for Texas with emissions calculated with TCEQ's TexN2 model.

- **Alaska Department of Environmental Conservation:** remove emissions as calculated by MOVES2014b for several equipment sector-county/census areas combinations in Alaska, due to an absence of nonroad activity (see Table 2).

Table 2. Alaska counties/census areas for which nonroad equipment sector-specific emissions are removed in 2016v1.

Nonroad Equipment Sector	Counties/Census Areas (FIPS) for which equipment sector emissions are removed in 2016v1
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)

Nonroad Equipment Sector	Counties/Census Areas (FIPS) for which equipment sector emissions are removed in 2016v1
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 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)

Emissions Inside California and Texas

California nonroad emissions were provided by the California Air Resources Board (CARB) for the years 2016, 2023, and 2028.

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.

Texas nonroad emissions were provided by the Texas Commission on Environmental Quality for the years 2016, 2023, and 2028, using TCEQ's TexN2 tool[10]. This tool facilitates the use of detailed Texas-specific nonroad equipment population, activity, fuels, and related data as inputs for MOVES2014b, and accounts for Texas-specific emission adjustments such as the Texas Low Emission Diesel (TxLED) program.

4. ANCILLARY DATA

Spatial Allocation

Spatial allocation of nonroad emissions to the national 36km and 12km domains used for air quality modeling is accomplished using spatial surrogates. Spatial surrogates map county polygons to the uniformly spaced grid cells of a modeling domain. Most nonroad emissions are allocated using spatial surrogates based on the National Landcover Database (NLCD). The

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[10] For more information on the TexN2 tool please see: ftp://amdaftp.tceq.texas.gov/EI/nonroad/TexN2/

remaining nonroad emissions are allocated using spatial surrogates for golf courses, mines, water, or total railroad density. Reports summarizing total emissions by spatial surrogate at the state and county level are included in the emissions modeling workgroup reports package. A national emissions summary by spatial surrogate is in Table 3.

Table 3. 2016 nonroad emissions by spatial surrogate (tons/yr; 36US3 domain)

Surrogate	Description	CO	NH$_3$	NO$_X$	PM$_{10}$	PM$_{2.5}$	SO$_2$	VOC
261	NTAD Total Railroad Density	4,961	3	2,157	230	222	2	431
304	NLCD Open + Low	66,368	4	1,836	165	159	5	2,988
305	NLCD Low + Med	1,683,707	95	16,298	4,224	3,866	129	116,725
306	NLCD Med + High	2,300,352	306	184,311	12,591	11,935	426	96,119
307	NLCD All Development	1,431,151	107	33,798	17,657	16,275	135	178,932
308	NLCD Low + Med + High	493,693	491	340,485	30,309	29,187	510	53,506
309	NLCD Open + Low + Med	2,205,710	131	22,947	1,487	1,367	178	49,881
310	NLCD Total Agriculture	320,175	366	347,896	26,857	25,991	408	38,673
320	NLCD Forest Land	31,715	15	6,020	719	674	15	3,666
321	NLCD Recreational Land	654,052	83	11,923	6,915	6,353	139	243,437
350	NLCD Water	1,469,214	184	121,152	7,670	6,929	248	365,285
850	Golf Courses	254,440	13	2,052	129	119	18	5,704
860	Mines	2,214	2	2,698	290	281	3	522

Temporal Allocation

Outside of California and Texas, monthly emissions are provided by MOVES2014b. Inside California, monthly temporalization is performed in SMOKE using temporal profiles that are specific to California and were first developed for the 2014v7.0 emissions modeling platform based on regional monthly factor data provided by OTAQ. Inside Texas, seasonal emissions are provided by TCEQ. Monthly emissions in Texas were set to the seasonal total, multiplied by a factor of (# of days in the month) / (# of days in the season). For example, in the "Summer"

season, which here represents June through August, the June emissions value is set to the Summer value multiplied by 30/92, and the July and August emissions values are set to the Summer value multiplied by 31/92.

Day-of-week and hour-of-day profiles are applied to all sources nationwide within SMOKE. The day-of-week profiles for nonroad allocate the same emissions to all weekdays Tuesday through Friday, allowing for use of "MWDSS" (Monday, WeekDay, Saturday, Sunday) representative dates, plus holidays. Reports summarizing total emissions according to the monthly, day-of-week, and hour-of-day temporal profile assignments are included in the emissions modeling workgroup reports package at the state and county level. A national emissions summary by weekly and diurnal temporal profile is in Table 4.

Table 4. 2016 nonroad emissions by weekly and diurnal temporal profile (tons/yr)

Weekly profile	Diurnal profile	CO	NH_3	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC
7	26	16,213	37	30,729	1,452	1,396	38	2,748
9	26	996,446	103	16,226	7,418	6,822	165	259,222
9	27	1,719,169	97	16,614	4,311	3,946	131	119,036
16	27	1,494,144	188	123,269	7,768	7,019	253	372,080
18	26	502,251	182	143,364	10,737	10,278	265	41,058
18	27	1,842,762	107	20,938	1,550	1,349	145	57,562
18	25a	320,747	367	348,360	26,894	26,027	409	38,724
19	24	4,971	3	2,161	230	223	2	431
19	25a	3,722,238	243	57,989	19,598	18,061	321	233,794
19	26a	500,909	500	346,328	30,804	29,666	519	54,355

Chemical Speciation

Outside of California and Texas, speciation profile assignments for VOC and $PM_{2.5}$ are determined by the MOVES2014b model. For each county/SCC, MOVES2014b outputs separate NONHAPTOG and $PM_{2.5}$ emissions totals by speciation profile (e.g. NONHAPTOG8754 for profile 8754, NONHAPTOG8769 for profile 8769, and so on). This allows SMOKE to perform a more accurate speciation than it otherwise could using traditional profiles. It also eliminates the need for SCC-specific profile assignments or a GSPRO_COMBO, at least outside of California and Texas, as all NONHAPTOG8754 emissions receive profile 8754 for all SCCs.

In most sectors that use HAP integration as part of VOC speciation, the only HAPs that are integrated are naphthalene, benzene, acetaldehyde, formaldehyde, and methanol, collectively

known as "NBAFM". The MOVES model uses a much longer set of integrate HAPs, shown in Table 5. The NONHAPTOG emissions in the nonroad inventory from MOVES incorporate the full MOVES set of HAPs. Since NONHAPTOG speciation profiles change depending on which HAPs are integrated, this means nonroad cannot use the same NONHAPTOG profiles as other sectors in the platform. Therefore, nonroad-specific NONHAPTOG profiles in which all HAPs listed in Table 5 are integrated, were created in the Speciation Tool and then included in the nonroad-specific GSPRO file. The nonroad GSPRO file also maps each MOVES integrate HAP to one or more CB6 model species.

Table 5. MOVES integrated species

MOVES ID	Pollutant Name
5	Methane (CH_4)
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

Inside California and Texas, datasets from CARB and TCEQ which do not have NONHAPTOG or PM2.5 pre-split by profile were used, and so traditional speciation profiles by VOC mode (exhaust and evaporative) are applied along with a GSPRO_COMBO to account for mixes of E0 and E10 fuel. When performing VOC HAP integration, SMOKE must use the same set of integrate HAPs for the entire sector. Therefore, when integrating HAP emissions in California, the full set of MOVES integrate HAPs is required, not just NBAFM, in California and Texas as well as the rest of the US. HAPs were not provided by CARB and TCEQ in these particular nonroad inventories, and so California and Texas did not employ VOC HAP integration. In California and Texas, $PM_{2.5}$ speciation uses separate profiles for gasoline, diesel, and natural gas combustion.

NOx is speciated to HONO (0.8%), NO (90%), and NO_2 (9.2%) for all nonroad sources nationwide.

5. EMISSIONS PROJECTION METHODS

Outside California and Texas, the MOVES2014b model was run separately for each future year, including 2023 and 2028, resulting in a separate inventory for each year. The fuels used are specific to each future year, but the meteorological data represented the year 2016. The resulting future year inventories were processed into the format needed by SMOKE in the same way as the base year emissions. Inside California and Texas, CARB and TCEQ provided separate datasets for each future year. Because the CARB and TCEQ inventories already reflect future year emissions, no additional work related to projections was required except to include them as SMOKE input files.

6. EMISSIONS PROCESSING REQUIREMENTS

Nonroad emissions were processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE[11]) modeling system. Three inventories were input to SMOKE: the California inventory from CARB, the Texas inventory from TCEQ, and the inventory for the rest of the country from MOVES2014b. Because the MOVES2014b inventory is monthly, the sector was processed through SMOKE as a monthly sector; i.e. Smkinven was run once per month with the appropriate SMKINVEN_MONTH setting (this is handled automatically by the platform scripts when using smk_ar_monthly_emf.csh). Spcmat, Grdmat, and Temporal were run once per month, followed by Smkmerge. This is a 2-D sector in which all emissions were output to a single layer gridded emissions file.

7. EMISSIONS SUMMARIES

National and state totals by pollutant for the beta platform cases are provided here (Tables 6-11), along with some example plots. Figures 1-6 display county-level annual 2016 nonroad emissions of criteria pollutants for the continental United States. Figures 7-12 display the gridded annual 2016 nonroad emissions of criteria pollutants within the 12-km CONUS domain.

Additional plots and maps are available online through the LADCO website[12] and the Intermountain West Data Warehouse[13].

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[11] http://www.smoke-model.org/index.cfm

[12] https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/

[13] http://views.cira.colostate.edu/iwdw/eibrowser2016

The case descriptions are as follows:

2014fd = 2014NEIv2 and 2014 NATA

2016fe = 2016 alpha platform (grown from 2014NEIv2)

2016ff, 2023ff, and 2028ff = 2016, 2023, and 2028 cases from the 2016 beta platform

2016fh, 2023fh, and 2028fh = 2016, 2023, and 2028 cases from the 2016 version 1 platform

Table 6. Comparison of national total annual CAPS nonroad emissions (tons/yr)

Pollutant	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
CO	12,614,644	12,419,558	11,089,466	10,801,647	11,154,989	10,797,055	11,526,892	11,118,735
NH3	2,252	2,297	1,822	1,873	2,005	2,064	2,076	2,137
NOX	1,393,217	1,219,766	1,102,956	1,123,088	741,087	747,082	615,637	619,916
PM10	142,017	123,887	110,458	110,774	73,747	72,650	60,761	59,436
PM2.5	134,428	117,081	104,500	104,716	69,058	68,056	56,546	55,327
SO2	3,176	2,453	2,243	2,167	1,556	1,549	1,573	1,568
VOC	1,662,430	1,495,541	1,175,789	1,152,885	892,850	875,010	839,719	819,501

Table 7. Comparison of state total annual NOx nonroad emissions (tons/yr)

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Alabama	18,740	16,539	10,916	10,930	7,889	7,895	7,124	7,129
Alaska	18,770	16,502	15,331	15,334	10,421	10,423	9,310	9,311
Arizona	47,615	41,461	25,819	25,792	18,932	18,919	16,676	16,667
Arkansas	47,088	41,733	43,898	43,489	30,366	30,108	24,026	23,854
California	14,517	12,779	9,849	9,882	6,097	6,114	4,736	4,748
Colorado	35,857	31,663	36,369	36,068	21,969	21,801	16,936	16,822
Connecticut	13,403	11,957	11,180	11,066	6,650	6,587	4,738	4,697
Delaware	27,545	24,379	24,016	23,853	13,399	13,312	9,392	9,336
D.C.	12,337	10,701	15,832	15,722	9,369	9,309	7,198	7,156
Florida	5,565	4,982	4,452	4,452	3,334	3,334	2,987	2,987
Georgia	25,055	21,965	21,139	21,115	15,248	15,233	13,306	13,295
Hawaii	6,087	5,348	5,778	5,784	3,797	3,800	3,051	3,053
Idaho	53,071	47,377	38,463	38,463	29,238	29,238	27,485	27,485
Illinois	32,556	28,213	26,849	26,883	19,741	19,763	18,046	18,060
Indiana	27,031	24,076	30,138	29,357	18,912	18,442	13,132	12,825
Iowa	53,056	44,917	40,920	40,831	27,170	27,120	22,450	22,417
Kansas	20,462	18,126	13,713	13,709	8,992	8,992	7,510	7,511
Kentucky	17,287	15,208	14,751	14,749	10,577	10,576	9,286	9,285
Louisiana	37,994	33,170	31,040	31,177	21,990	22,071	18,689	18,748
Maine	2,901	2,555	2,326	2,327	1,586	1,586	1,390	1,390
Maryland	19,247	16,785	14,932	14,931	10,351	10,350	9,188	9,188
Massachusetts	19,250	17,127	15,592	15,387	9,614	9,493	6,855	6,762

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Michigan	25,953	22,645	20,000	20,062	13,156	13,188	11,236	11,258
Minnesota	137,784	111,281	71,095	98,007	47,965	58,442	41,054	48,763
Mississippi	9,790	8,632	7,306	7,133	5,576	5,308	5,128	4,797
Missouri	2,777	2,488	5,066	5,067	3,481	3,481	2,823	2,823
Montana	28,932	25,258	22,167	22,137	14,249	14,235	12,052	12,042
Nebraska	28,470	25,116	24,517	24,567	16,290	16,319	13,784	13,803
Nevada	5,367	4,745	3,591	3,592	2,661	2,662	2,348	2,348
New Hampshire	35,182	30,888	24,069	24,084	16,562	16,571	13,896	13,902
New Jersey	3,578	3,216	2,255	2,256	1,604	1,604	1,350	1,350
New Mexico	7,863	6,950	6,417	6,417	4,799	4,799	4,400	4,400
New York	398	352	331	331	231	231	197	197
North Carolina	18,740	16,539	10,916	10,930	7,889	7,895	7,124	7,129
North Dakota	18,770	16,502	15,331	15,334	10,421	10,423	9,310	9,311
Ohio	47,615	41,461	25,819	25,792	18,932	18,919	16,676	16,667
Oklahoma	47,088	41,733	43,898	43,489	30,366	30,108	24,026	23,854
Oregon	14,517	12,779	9,849	9,882	6,097	6,114	4,736	4,748
Pennsylvania	35,857	31,663	36,369	36,068	21,969	21,801	16,936	16,822
Rhode Island	13,403	11,957	11,180	11,066	6,650	6,587	4,738	4,697
South Carolina	27,545	24,379	24,016	23,853	13,399	13,312	9,392	9,336
South Dakota	12,337	10,701	15,832	15,722	9,369	9,309	7,198	7,156
Tennessee	5,565	4,982	4,452	4,452	3,334	3,334	2,987	2,987
Texas	25,055	21,965	21,139	21,115	15,248	15,233	13,306	13,295
Utah	6,087	5,348	5,778	5,784	3,797	3,800	3,051	3,053
Vermont	53,071	47,377	38,463	38,463	29,238	29,238	27,485	27,485
Virginia	32,556	28,213	26,849	26,883	19,741	19,763	18,046	18,060
Washington	27,031	24,076	30,138	29,357	18,912	18,442	13,132	12,825
West Virginia	53,056	44,917	40,920	40,831	27,170	27,120	22,450	22,417
Wisconsin	20,462	18,126	13,713	13,709	8,992	8,992	7,510	7,511
Wyoming	17,287	15,208	14,751	14,749	10,577	10,576	9,286	9,285
Puerto Rico	37,994	33,170	31,040	31,177	21,990	22,071	18,689	18,748
Virgin Islands	2,901	2,555	2,326	2,327	1,586	1,586	1,390	1,390

Table 8. Comparison of state total annual VOC nonroad emissions (tons/yr)

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Alabama	32,349	29,060	21,829	21,836	15,669	15,673	14,295	14,298
Alaska	14,862	13,387	8,522	8,474	5,832	5,791	5,265	5,224
Arizona	29,885	27,165	21,810	18,147	18,022	14,365	17,395	13,680
Arkansas	23,204	20,739	13,871	13,887	10,458	10,466	9,835	9,840
California	107,496	92,270	92,270	81,829	66,502	66,500	60,723	60,721
Colorado	25,030	23,104	19,104	19,106	17,614	17,616	18,199	18,201
Connecticut	13,181	11,989	10,558	8,833	7,987	7,185	7,399	6,851
Delaware	4,503	3,943	7,151	7,152	4,694	4,694	4,095	4,095
D.C.	950	859	539	539	439	439	433	433

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Florida	119,571	106,686	98,385	98,168	72,860	72,703	68,322	68,194
Georgia	44,677	40,678	33,466	33,670	26,913	27,098	25,893	26,082
Hawaii	4,313	3,824	4,365	4,366	3,253	3,253	3,012	3,013
Idaho	16,513	14,822	11,426	11,429	8,199	8,200	7,472	7,474
Illinois	56,743	51,130	38,521	38,430	30,136	30,088	28,484	28,451
Indiana	32,772	29,903	20,425	20,404	16,695	16,685	15,980	15,974
Iowa	22,037	20,062	15,398	15,350	11,294	11,267	10,372	10,355
Kansas	13,638	12,433	9,397	9,352	7,186	7,164	6,678	6,664
Kentucky	23,985	21,498	14,468	14,375	10,535	10,467	9,697	9,640
Louisiana	35,217	31,147	20,508	20,513	13,807	13,810	12,181	12,183
Maine	22,165	19,960	17,730	17,730	11,597	11,597	10,285	10,285
Maryland	25,859	23,520	17,992	17,994	14,530	14,531	14,015	14,016
Massachusetts	26,895	24,070	19,296	19,296	14,750	14,750	13,807	13,807
Michigan	103,089	93,761	53,280	53,275	37,242	37,239	33,846	33,843
Minnesota	68,309	63,319	52,067	52,025	36,430	36,406	33,220	33,205
Mississippi	22,374	19,972	9,888	9,892	6,928	6,931	6,255	6,257
Missouri	35,332	31,780	24,028	23,998	17,429	17,414	15,867	15,857
Montana	9,210	8,298	6,045	6,034	4,386	4,380	4,015	4,012
Nebraska	10,765	9,768	8,133	8,116	5,861	5,852	5,267	5,261
Nevada	12,295	11,375	10,518	10,500	9,022	9,008	8,788	8,776
New Hampshire	12,598	11,404	9,104	9,103	6,542	6,542	6,024	6,024
New Jersey	30,068	27,513	24,847	24,843	19,155	19,152	18,028	18,025
New Mexico	8,022	7,235	5,358	5,360	4,370	4,372	4,183	4,184
New York	85,444	75,948	53,331	53,331	42,839	42,839	41,568	41,568
North Carolina	46,875	42,144	34,586	34,589	26,735	26,737	25,313	25,314
North Dakota	8,728	7,925	7,500	7,421	5,567	5,524	5,020	4,992
Ohio	56,416	51,612	38,182	38,173	29,324	29,320	27,289	27,287
Oklahoma	20,885	18,799	16,118	16,118	12,339	12,339	11,666	11,666
Oregon	23,686	21,070	16,334	16,333	13,657	13,656	13,519	13,517
Pennsylvania	57,142	52,102	35,979	36,000	29,054	29,070	27,681	27,694
Rhode Island	3,850	3,390	2,443	2,443	1,815	1,815	1,673	1,673
South Carolina	25,981	23,302	23,603	23,602	17,080	17,080	15,672	15,672
South Dakota	7,945	7,241	5,611	5,591	3,932	3,922	3,500	3,494
Tennessee	34,300	30,974	23,324	23,333	17,375	17,380	16,214	16,218
Texas	79,817	71,294	67,341	63,847	57,813	47,811	58,229	45,941
Utah	17,728	15,874	11,968	8,948	9,825	6,760	9,821	6,356
Vermont	7,630	6,897	4,896	4,896	3,667	3,667	3,447	3,447
Virginia	35,131	31,907	26,637	26,631	20,667	20,662	19,221	19,217
Washington	36,244	32,395	25,527	25,488	19,890	19,852	19,161	19,123
West Virginia	12,384	11,128	5,679	5,679	4,539	4,539	4,336	4,336
Wisconsin	72,250	64,965	40,898	40,903	27,825	27,829	24,727	24,730
Wyoming	6,849	6,183	4,180	4,180	3,076	3,076	2,885	2,885
Puerto Rico	14,606	13,162	10,891	10,891	9,151	9,151	9,125	9,125
Virgin Islands	631	554	464	464	342	342	320	320

Table 9. 2016 total nonroad carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC), ammonia (NH₃), sulfur dioxide (SO₂), and particulate matter (PM₂.₅) emissions by state, annual emissions (tons/yr)

FIPS	State	CO	NH$_3$	NOx	PM$_{2.5}$	SO$_2$	VOC
1000	Alabama	179,622	30	17,530	1,655	36	21,836
2000	Alaska	33,882	6	2,600	358	7	8,474
4000	Arizona	185,674	37	22,679	2,113	38	18,147
5000	Arkansas	121,598	27	20,903	1,661	33	13,887
6000	California	605,710	66	87,516	6,096	57	81,829
8000	Colorado	228,916	29	13,670	1,756	35	19,106
9000	Connecticut	114,949	14	7,840	791	18	8,833
10000	Delaware	52,149	7	3,741	293	9	7,152
11000	District of	7,500	1	664	73	1	539
12000	Florida	900,953	133	67,817	6,664	157	98,168
13000	Georgia	352,088	52	26,830	2,819	57	33,670
15000	Hawaii	47,333	7	3,463	324	8	4,366
16000	Idaho	79,749	14	7,871	838	17	11,429
17000	Illinois	442,328	80	49,926	4,576	95	38,430
18000	Indiana	239,022	57	37,287	3,250	67	20,404
19000	Iowa	141,128	44	31,045	2,741	50	15,350
20000	Kansas	111,303	32	25,373	2,165	37	9,352
21000	Kentucky	127,597	21	12,518	1,183	25	14,375
22000	Louisiana	146,415	21	12,241	1,104	26	20,513
23000	Maine	92,124	14	6,622	694	18	17,730
24000	Maryland	211,115	22	10,930	1,287	28	17,994
25000	Massachusetts	229,432	28	15,334	1,578	36	19,296
26000	Michigan	359,837	53	25,792	2,927	67	53,275
27000	Minnesota	305,944	73	43,489	4,223	86	52,025
28000	Mississippi	80,633	16	9,882	959	19	9,892
29000	Missouri	238,735	49	36,068	2,980	58	23,998
30000	Montana	47,213	14	11,066	974	16	6,034
31000	Nebraska	85,726	28	23,853	1,890	32	8,116
32000	Nevada	120,270	27	15,722	1,654	31	10,500
33000	New Hampshire	67,910	10	4,452	506	12	9,103
34000	New Jersey	297,888	43	21,115	2,099	52	24,843
35000	New Mexico	58,437	11	5,784	608	12	5,360
36000	New York	561,467	75	38,463	3,791	95	53,331
37000	North Carolina	357,871	52	26,883	2,734	64	34,589
38000	North Dakota	69,704	39	29,357	2,305	43	7,421
39000	Ohio	406,165	69	40,831	3,734	83	38,173
40000	Oklahoma	166,560	23	13,709	1,358	29	16,118
41000	Oregon	184,645	28	14,749	1,493	34	16,333

FIPS	State	CO	NH₃	NOx	PM₂.₅	SO₂	VOC
42000	Pennsylvania	409,724	61	31,177	3,347	74	36,000
72000	Puerto Rico	122,846	14	6,417	770	18	10,891
44000	Rhode Island	29,129	4	2,327	216	5	2,443
45000	South Carolina	201,749	26	14,931	1,412	33	23,602
46000	South Dakota	44,443	20	15,387	1,274	22	5,591
47000	Tennessee	217,453	34	20,062	1,857	42	23,333
48000	Texas	701,452	203	98,007	8,499	191	63,847
49000	Utah	88,827	14	7,133	718	17	8,948
50000	Vermont	33,318	10	5,067	500	11	4,896
78000	Virgin Islands	4,312	1	331	34	1	464
51000	Virginia	299,518	40	22,137	2,372	49	26,631
53000	Washington	251,166	40	24,567	2,347	49	25,488
54000	West Virginia	52,492	7	3,592	415	9	5,679
55000	Wisconsin	260,045	44	24,084	2,442	54	40,903
56000	Wyoming	25,579	4	2,256	258	5	4,180
	Total	10,801,64	1,873	1,123,088	104,716	2,167	1,152,885

Table 10. 2023 total nonroad carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC), ammonia (NH₃), sulfur dioxide (SO₂), and particulate matter (PM₂.₅) emissions by state, annual emissions (tons/yr)

FIPS	State	CO	NH₃	NOx	PM₂.₅	SO₂	VOC
1000	Alabama	178,562	32	11,227	1,025	24	15,673
2000	Alaska	30,492	7	1,972	240	4	5,791
4000	Arizona	190,278	42	13,537	1,337	33	14,365
5000	Arkansas	119,910	23	12,128	938	20	10,466
6000	California	629,026	77	62,722	4,298	67	66,500
8000	Colorado	247,922	33	9,772	1,342	24	17,616
9000	Connecticut	113,627	16	5,446	568	12	7,185
10000	Delaware	53,899	7	3,018	213	5	4,694
11000	District of	7,647	1	390	40	1	439
12000	Florida	956,252	156	48,391	4,715	111	72,703
13000	Georgia	365,876	60	18,172	1,998	45	27,098
15000	Hawaii	48,466	8	2,455	235	6	3,253
16000	Idaho	77,175	15	5,567	558	11	8,200
17000	Illinois	435,416	86	31,526	2,888	69	30,088
18000	Indiana	239,190	64	23,240	1,972	54	16,685
19000	Iowa	136,696	47	19,827	1,683	41	11,267
20000	Kansas	106,185	34	14,391	1,161	29	7,164
21000	Kentucky	125,092	23	8,447	735	18	10,467
22000	Louisiana	141,355	22	8,454	668	15	13,810

FIPS	State	CO	NH₃	NOx	PM₂.₅	SO₂	VOC
23000	Maine	86,371	15	5,092	454	10	11,597
24000	Maryland	215,559	25	7,895	976	17	14,531
25000	Massachusetts	227,652	31	10,423	1,084	23	14,750
26000	Michigan	338,029	56	18,919	1,989	41	37,239
27000	Minnesota	291,183	78	30,108	2,773	62	36,406
28000	Mississippi	77,059	16	6,114	588	13	6,931
29000	Missouri	229,472	51	21,801	1,696	41	17,414
30000	Montana	45,131	14	6,587	558	12	4,380
31000	Nebraska	81,083	28	13,312	956	25	5,852
32000	Nevada	124,744	31	9,309	1,075	25	9,008
33000	New Hampshire	66,049	11	3,334	362	7	6,542
34000	New Jersey	296,604	50	15,233	1,507	38	19,152
35000	New Mexico	58,920	12	3,800	398	9	4,372
36000	New York	588,967	86	29,238	2,702	65	42,839
37000	North Carolina	368,545	59	19,763	1,916	46	26,737
38000	North Dakota	68,194	40	18,442	1,371	36	5,524
39000	Ohio	398,342	76	27,120	2,422	60	29,320
40000	Oklahoma	169,359	26	8,992	902	19	12,339
41000	Oregon	198,697	33	10,576	1,073	25	13,656
42000	Pennsylvania	405,486	68	22,071	2,396	53	29,070
72000	Puerto Rico	132,193	17	4,799	618	12	9,151
44000	Rhode Island	28,491	5	1,586	144	4	1,815
45000	South Carolina	205,680	28	10,350	952	20	17,080
46000	South Dakota	41,479	21	9,493	727	18	3,922
47000	Tennessee	218,354	39	13,188	1,215	30	17,380
48000	Texas	628,956	222	58,442	4,499	118	47,811
49000	Utah	93,416	16	5,308	514	13	6,760
50000	Vermont	32,505	12	3,481	334	10	3,667
78000	Virgin Islands	4,529	1	231	23	1	342
51000	Virginia	293,639	43	14,235	1,626	31	20,662
53000	Washington	259,756	43	16,319	1,573	33	19,852
54000	West Virginia	52,265	8	2,662	302	6	4,539
55000	Wisconsin	242,011	48	16,571	1,547	35	27,829
56000	Wyoming	25,271	5	1,604	169	3	3,076
	Total	10,797,05	2,064	747,082	68,056	1,549	875,010

Table 11. 2028 total nonroad carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC), ammonia (NH₃), sulfur dioxide (SO₂), and particulate matter (PM₂.₅) emissions by state, annual emissions (tons/yr)

FIPS	State	CO	NH$_3$	NOx	PM$_{2.5}$	SO$_2$	VOC
1000	Alabama	182,983	33	9,468	830	24	14,298
2000	Alaska	29,854	7	1,722	200	4	5,224
4000	Arizona	197,877	44	10,842	1,020	33	13,680
5000	Arkansas	122,316	22	8,968	714	18	9,840
6000	California	648,287	84	52,207	3,472	72	60,721
8000	Colorado	266,485	35	8,577	1,228	24	18,201
9000	Connecticut	115,091	17	4,849	493	13	6,851
10000	Delaware	56,348	8	2,718	194	5	4,095
11000	District of	8,019	1	334	31	1	433
12000	Florida	1,014,323	163	41,915	4,113	114	68,194
13000	Georgia	382,758	62	15,561	1,735	46	26,082
15000	Hawaii	50,095	8	2,088	201	6	3,013
16000	Idaho	77,708	15	4,463	436	11	7,474
17000	Illinois	442,780	88	25,563	2,308	69	28,451
18000	Indiana	245,395	65	18,381	1,536	54	15,974
19000	Iowa	138,639	47	14,337	1,135	39	10,355
20000	Kansas	106,567	34	10,427	804	28	6,664
21000	Kentucky	127,381	24	7,275	606	18	9,640
22000	Louisiana	142,247	23	7,232	538	16	12,183
23000	Maine	86,042	15	4,581	399	10	10,285
24000	Maryland	222,868	26	7,129	891	17	14,016
25000	Massachusetts	232,306	32	9,311	926	24	13,807
26000	Michigan	337,550	57	16,667	1,669	41	33,843
27000	Minnesota	293,067	79	23,854	2,063	60	33,205
28000	Mississippi	77,276	16	4,748	435	13	6,257
29000	Missouri	229,685	51	16,822	1,291	40	15,857
30000	Montana	45,342	14	4,697	373	11	4,012
31000	Nebraska	80,747	29	9,336	639	24	5,261
32000	Nevada	128,548	32	7,156	844	24	8,776
33000	New Hampshire	66,867	11	2,987	318	8	6,024
34000	New Jersey	301,058	51	13,295	1,299	38	18,025
35000	New Mexico	60,031	12	3,053	323	9	4,184
36000	New York	615,575	92	27,485	2,444	68	41,568
37000	North Carolina	386,459	63	18,060	1,694	49	25,314
38000	North Dakota	68,310	40	12,825	866	34	4,992
39000	Ohio	402,156	78	22,417	1,960	60	27,287

FIPS	State	CO	NH₃	NOx	PM₂.₅	SO₂	VOC
40000	Oklahoma	175,708	27	7,511	759	19	11,666
41000	Oregon	212,977	35	9,285	925	26	13,517
42000	Pennsylvania	410,579	70	18,748	2,013	53	27,694
72000	Puerto Rico	141,623	18	4,400	584	12	9,125
44000	Rhode Island	28,860	5	1,390	120	4	1,673
45000	South Carolina	213,735	30	9,188	831	21	15,672
46000	South Dakota	41,149	21	6,762	462	17	3,494
47000	Tennessee	225,332	40	11,258	1,010	31	16,218
48000	Texas	655,946	235	48,763	3,514	123	45,941
49000	Utah	99,328	17	4,797	455	13	6,356
50000	Vermont	32,962	12	2,823	265	9	3,447
78000	Virgin Islands	4,765	1	197	20	1	320
51000	Virginia	295,194	44	12,042	1,364	32	19,217
53000	Washington	273,066	45	13,803	1,321	34	19,123
54000	West Virginia	53,044	8	2,348	260	6	4,336
55000	Wisconsin	239,608	49	13,902	1,253	36	24,730
56000	Wyoming	25,817	5	1,350	139	3	2,885
	Total	11,118,73	2,137	619,916	55,327	1,568	819,501
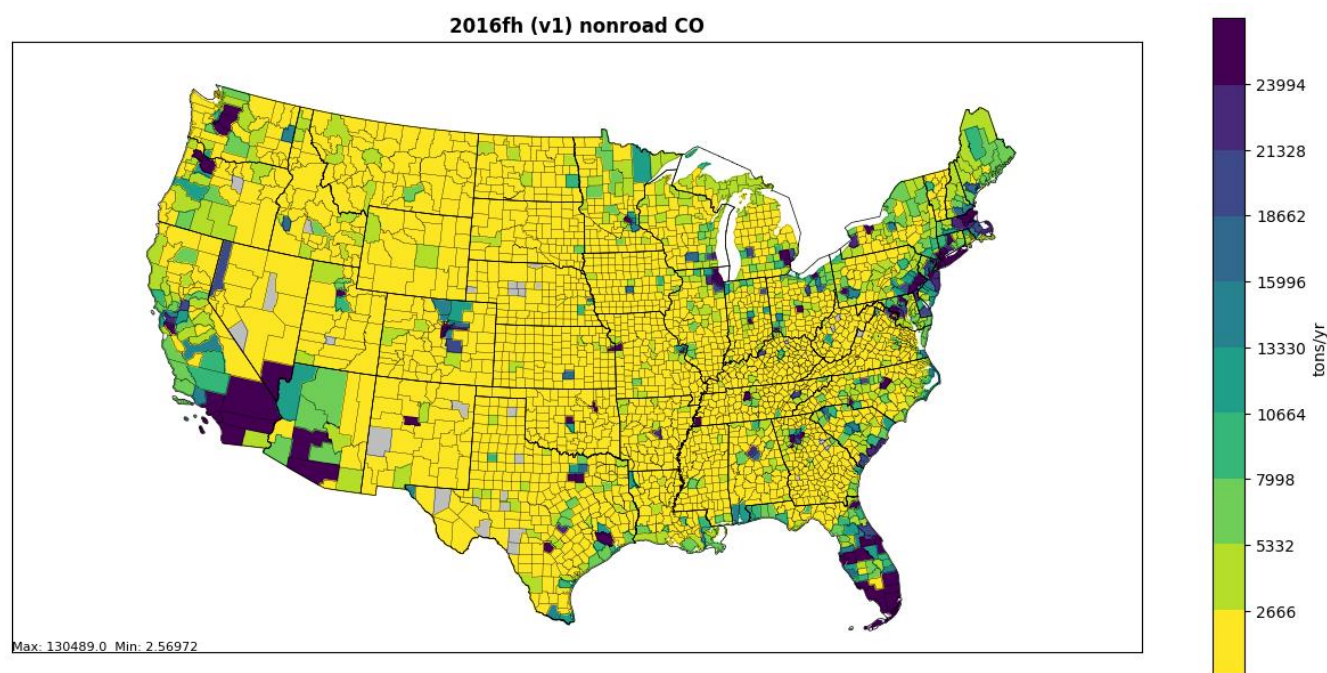
Figure 1. County-level nonroad emissions of CO for 2016
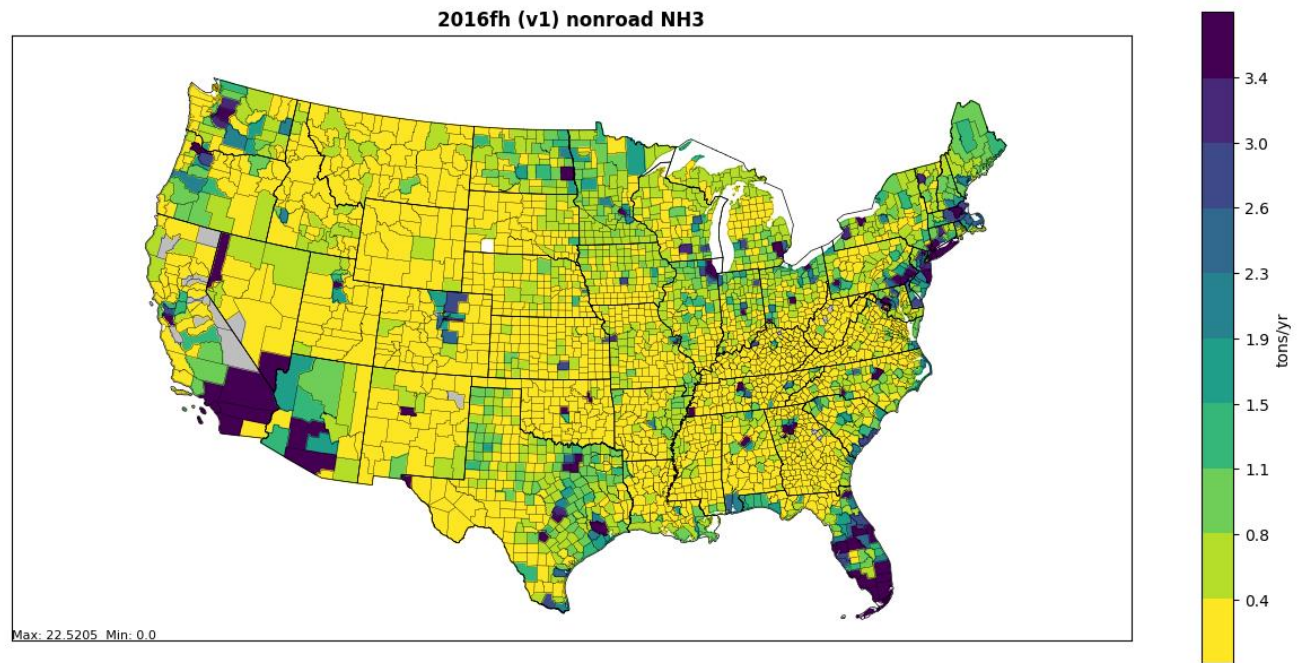
Figure 2. County-level nonroad emissions of NH₃ for 2016
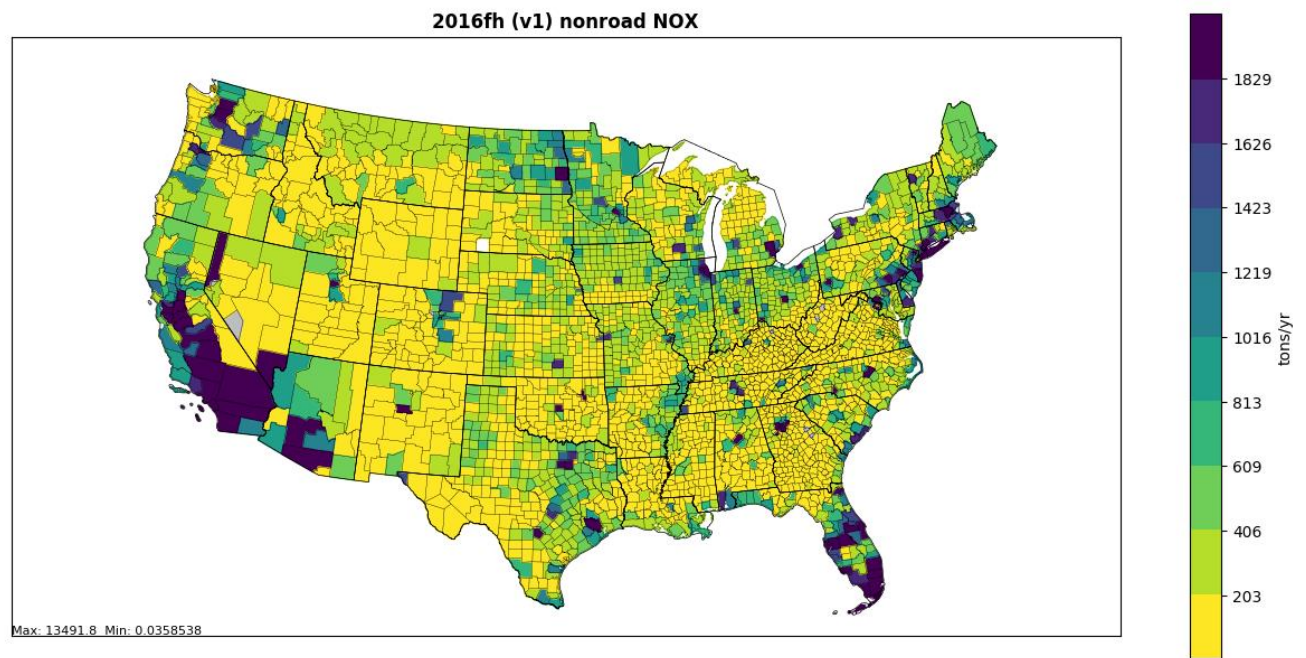
Figure 3. County-level nonroad emissions of NOx for 2016
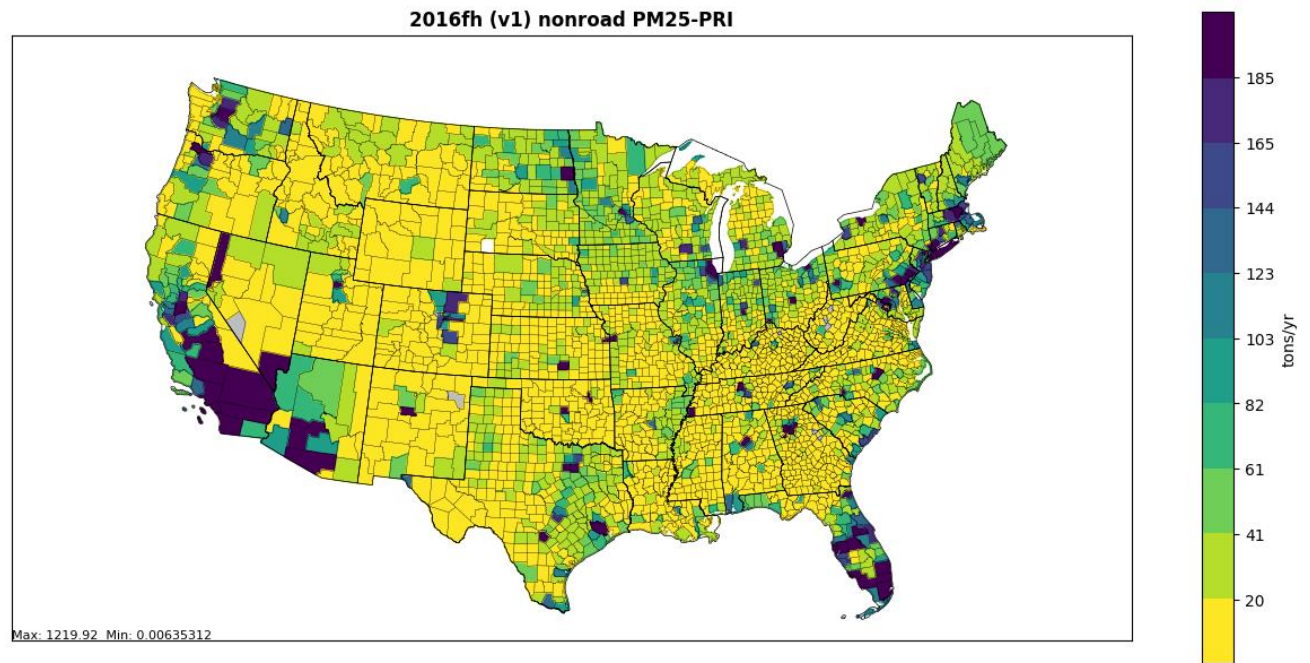
Figure 4. County-level nonroad emissions of PM$_{2.5}$ for 2016
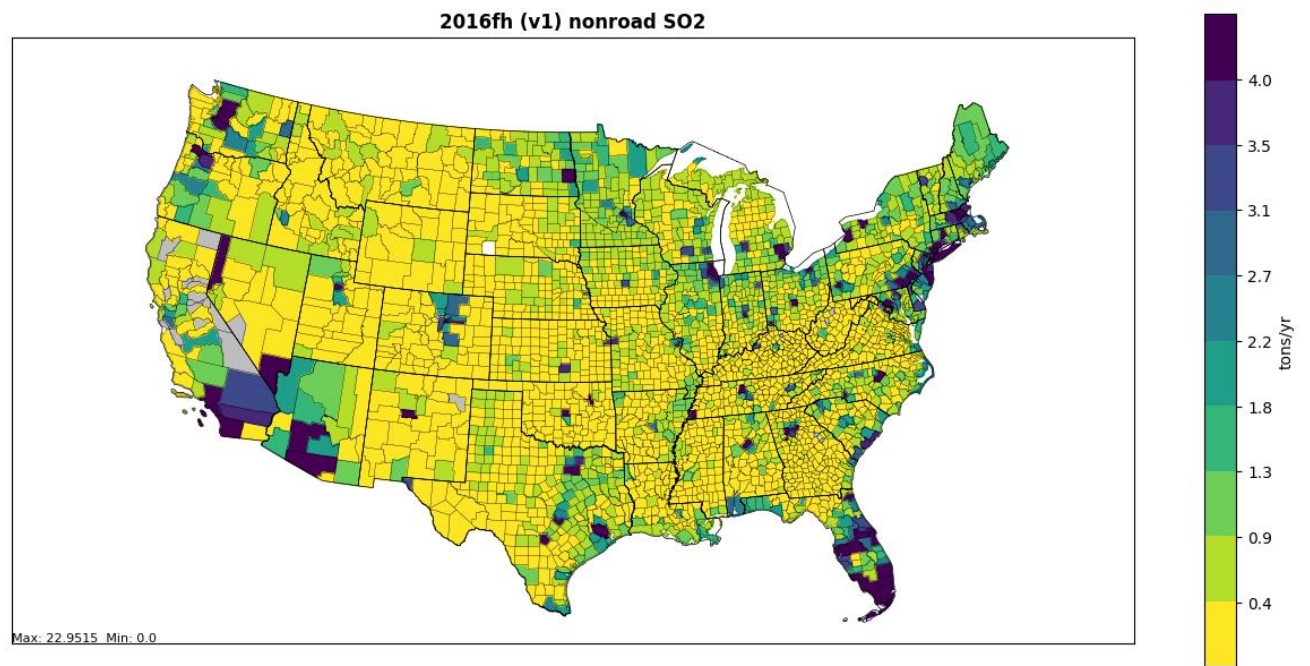

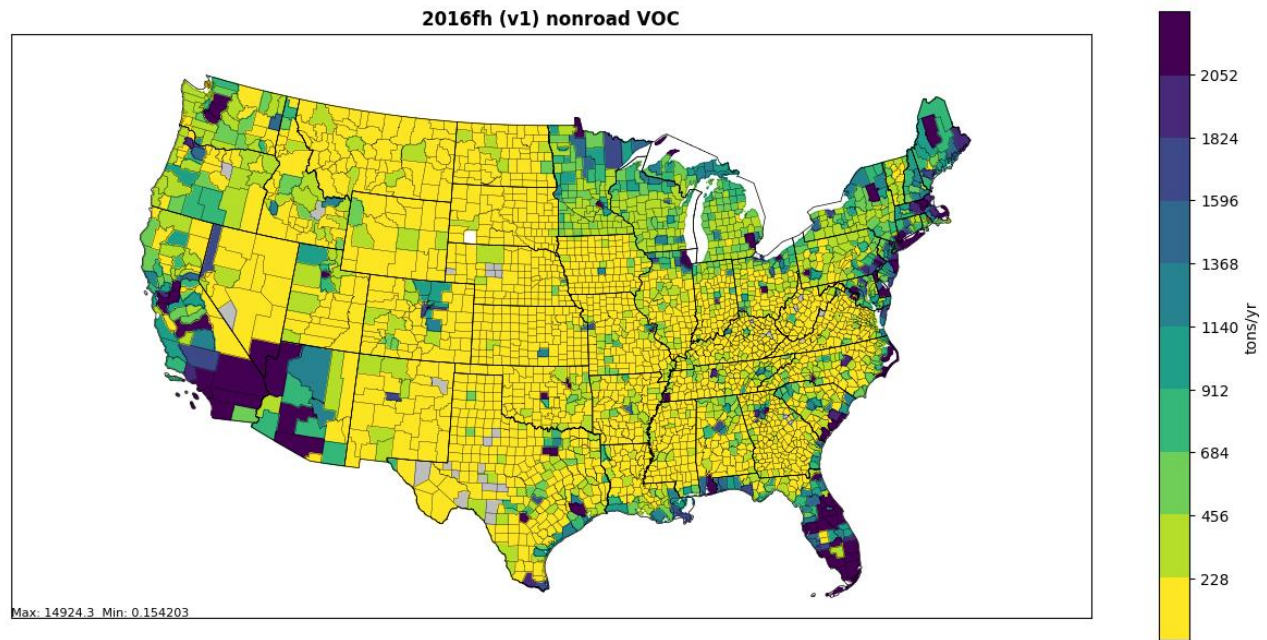**Figure 5. County-level nonroad emissions of SO$_2$ for 2016.**
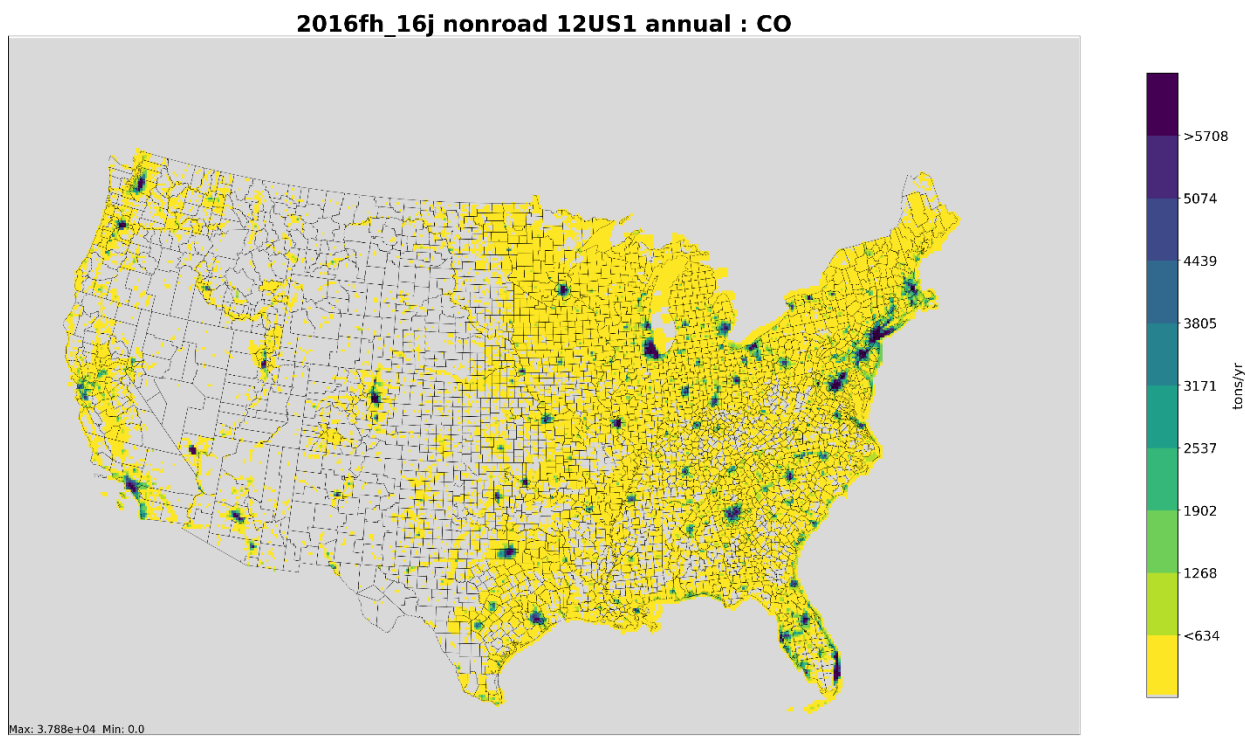
Figure 6. County-level nonroad emissions of VOC for 2016

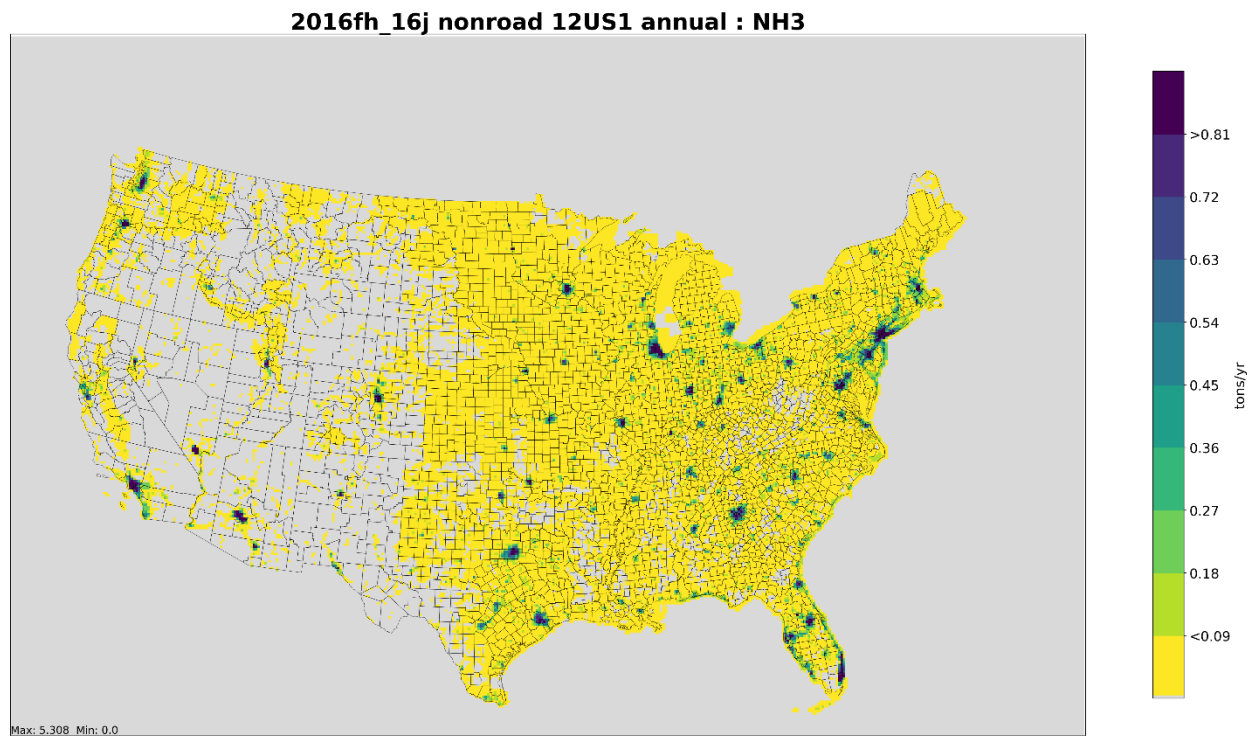**Figure 7. Annual nonroad emissions of CO across the 12-km CONUS domain for 2016**

2016fh_16j nonroad 12US1 annual : NH3

Figure 8. Annual nonroad emissions of NH₃ across the 12-km CONUS domain for 2016

2016fh_16j nonroad 12US1 annual : NOX
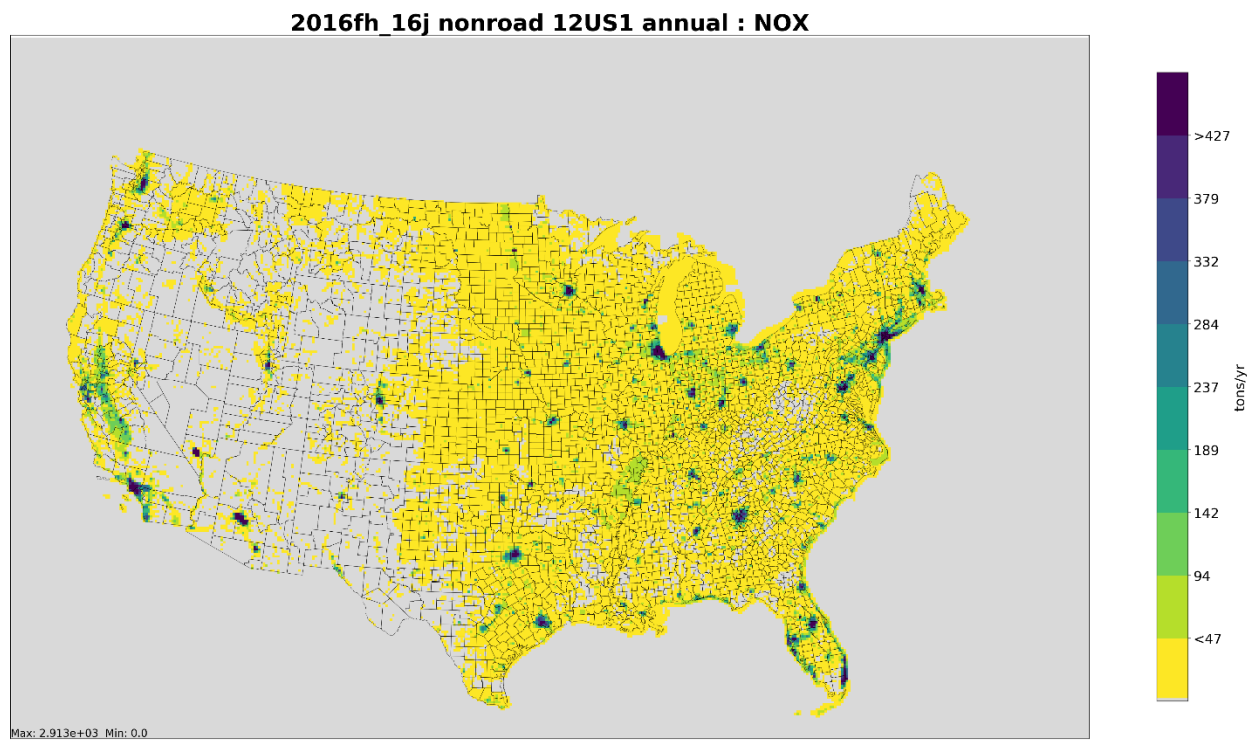
Figure 9. Annual nonroad emissions of NOx across the 12-km CONUS domain for 2016

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2016fh_16j nonroad 12US1 annual : PM2_5
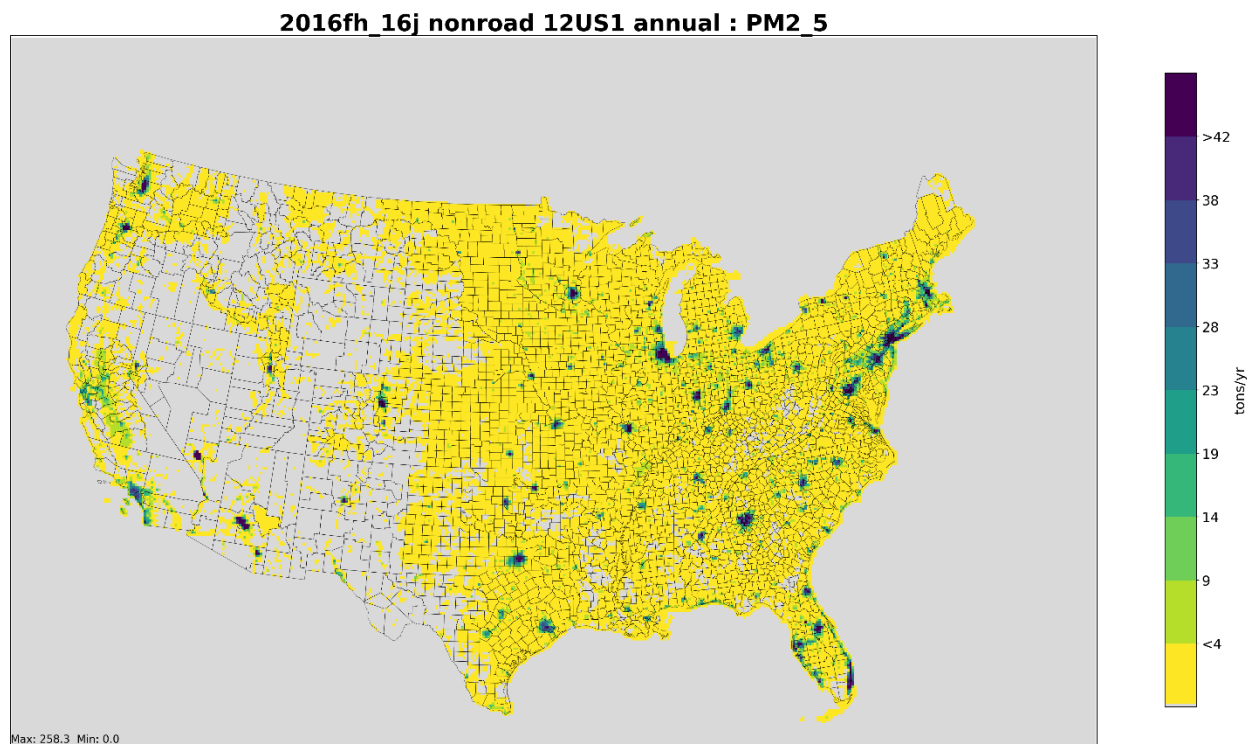
Figure 10. Annual nonroad emissions of PM$_{2.5}$ across the 12-km CONUS domain for 2016

2016fh_16j nonroad 12US1 annual : SO2
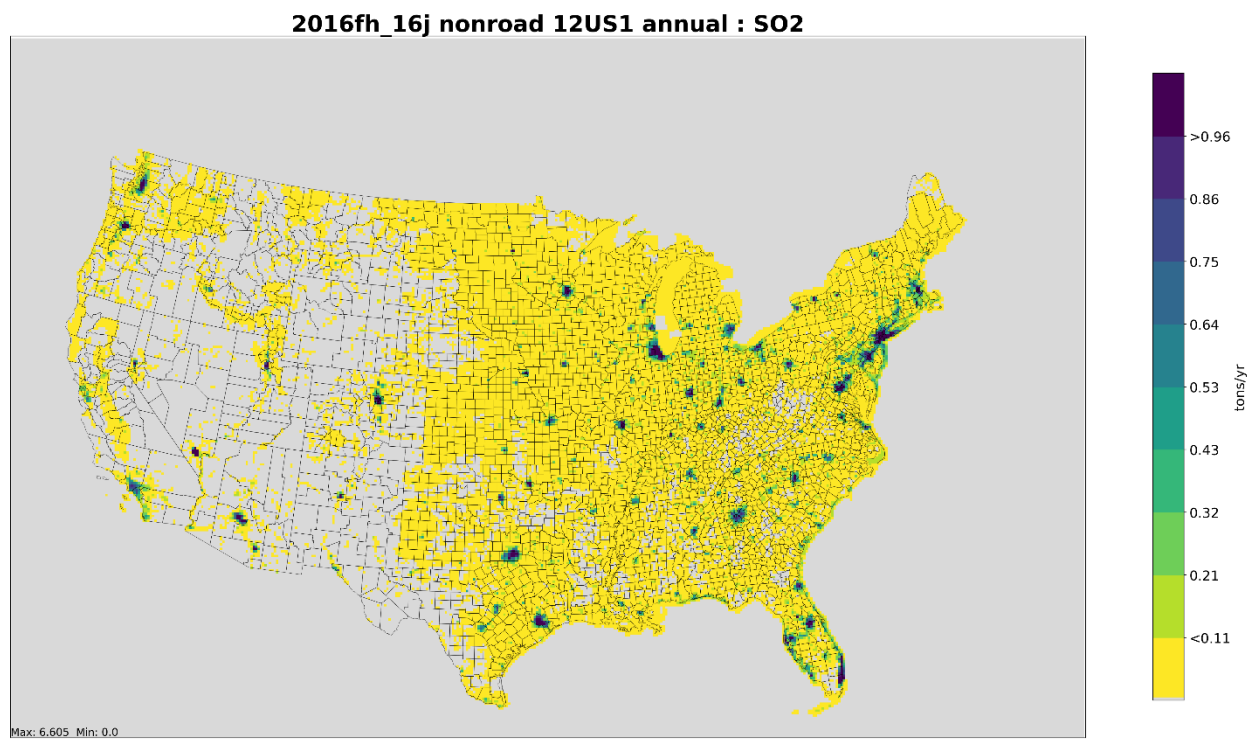
Figure 11. Annual nonroad emissions of SO$_2$ across the 12-km CONUS domain for 2016

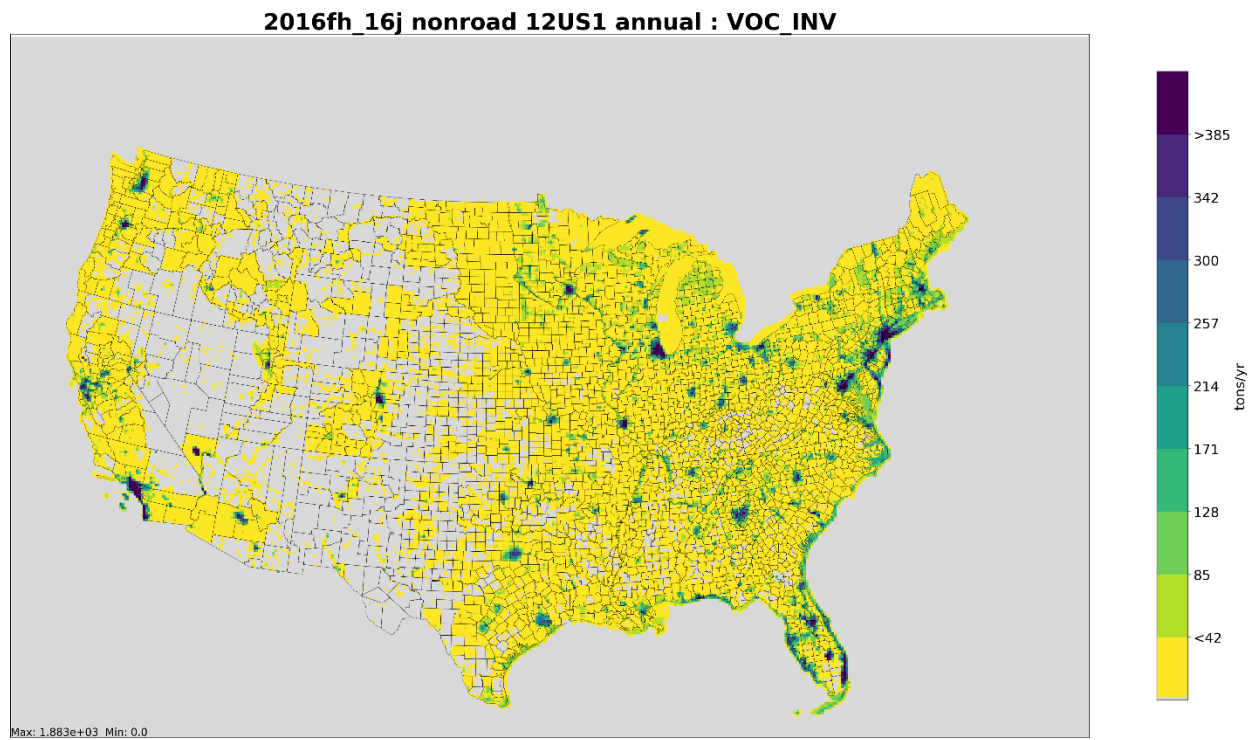**2016fh_16j nonroad 12US1 annual : VOC_INV**

Figure 12. Annual nonroad emissions of VOC across the 12-km CONUS domain for 2016

APPENDIX A: AGGREGATED NONROAD SCCS FOR USE IN SMOKE

Table A-1. Nonroad Agricultural Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2260005022	2-Stroke Agricultural Equipment	2-Wheel Tractors, Agricultural Tractors, Combines, Balers, Agricultural Mowers, Sprayers, Tillers > 6HP, Swathers, Irrigation Sets, Other Agricultural Equipment
2265005022	4-Stroke Agricultural Equipment	2-Wheel Tractors, Agricultural Tractors, Combines, Balers, Agricultural Mowers, Sprayers, Tillers > 6HP, Swathers, Irrigation Sets, Other Agricultural Equipment
2267005022	LPG Agricultural Equipment	2-Wheel Tractors, Agricultural Tractors, Combines, Balers, Agricultural Mowers, Sprayers, Tillers > 6HP, Swathers, Irrigation Sets, Other Agricultural Equipment
2268005022	CNG Agricultural Equipment	2-Wheel Tractors, Agricultural Tractors, Combines, Balers, Agricultural Mowers, Sprayers, Tillers > 6HP, Swathers, Irrigation Sets, Other Agricultural Equipment
2270005022	Diesel Agricultural Equipment	2-Wheel Tractors, Agricultural Tractors, Combines, Balers, Agricultural Mowers, Sprayers, Tillers > 6HP, Swathers, Irrigation Sets, Other Agricultural Equipment

Table A-2. Nonroad Construction Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2260002022	2-Stroke Construction Equipment	Asphalt Pavers, Tampers/Rammers, Plate Compactors, Rollers, Scrapers, Paving Equipment, Surfacing Equipment, Signal Boards, Trenchers, Bore/Drill Rigs, Excavators, Concrete/Industrial Saws, Cement & Mortar Mixers, Cranes, Graders, Off-Highway Trucks, Crushing/Proc. Equipment, Rough Terrain Forklifts, Rubber Tire Loaders, Rubber Tire Dozers, Tractors/Loaders/Backhoes, Crawler Dozers, Skid Steer Loaders, Off-Highway Tractors, Dumpers/Tenders, Other Construction Equipment
2265002022	4-Stroke Construction Equipment	Asphalt Pavers, Tampers/Rammers, Plate Compactors, Rollers, Scrapers, Paving Equipment, Surfacing Equipment, Signal Boards, Trenchers, Bore/Drill Rigs, Excavators, Concrete/Industrial Saws, Cement & Mortar Mixers, Cranes, Graders, Off-Highway Trucks, Crushing/Proc. Equipment, Rough Terrain Forklifts, Rubber Tire Loaders, Rubber Tire Dozers, Tractors/Loaders/Backhoes, Crawler Dozers, Skid Steer Loaders, Off-Highway Tractors, Dumpers/Tenders, Other Construction Equipment
2267002022	LPG Construction Equipment	Asphalt Pavers, Tampers/Rammers, Plate Compactors, Rollers, Scrapers, Paving Equipment, Surfacing Equipment, Signal Boards, Trenchers, Bore/Drill Rigs, Excavators, Concrete/Industrial Saws, Cement & Mortar Mixers, Cranes, Graders, Off-Highway Trucks, Crushing/Proc. Equipment, Rough Terrain Forklifts, Rubber Tire

Aggregated SCC	SCC Description	Equipment Types
		Loaders, Rubber Tire Dozers, Tractors/Loaders/Backhoes, Crawler Dozers, Skid Steer Loaders, Off-Highway Tractors, Dumpers/Tenders, Other Construction Equipment
2268002022	CNG Construction Equipment	Asphalt Pavers, Tampers/Rammers, Plate Compactors, Rollers, Scrapers, Paving Equipment, Surfacing Equipment, Signal Boards, Trenchers, Bore/Drill Rigs, Excavators, Concrete/Industrial Saws, Cement & Mortar Mixers, Cranes, Graders, Off-Highway Trucks, Crushing/Proc. Equipment, Rough Terrain Forklifts, Rubber Tire Loaders, Rubber Tire Dozers, Tractors/Loaders/Backhoes, Crawler Dozers, Skid Steer Loaders, Off-Highway Tractors, Dumpers/Tenders, Other Construction Equipment
2270002022	Diesel Construction Equipment	Asphalt Pavers, Tampers/Rammers, Plate Compactors, Rollers, Scrapers, Paving Equipment, Surfacing Equipment, Signal Boards, Trenchers, Bore/Drill Rigs, Excavators, Concrete/Industrial Saws, Cement & Mortar Mixers, Cranes, Graders, Off-Highway Trucks, Crushing/Proc. Equipment, Rough Terrain Forklifts, Rubber Tire Loaders, Rubber Tire Dozers, Tractors/Loaders/Backhoes, Crawler Dozers, Skid Steer Loaders, Off-Highway Tractors, Dumpers/Tenders, Other Construction Equipment

Table A-3. Nonroad Industrial Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2260003022	2-Stroke Industrial Equipment	Aerial Lifts, Forklifts, Sweepers/Scrubbers, Other General Industrial Equipment, Other Material Handling Equipment, Terminal Tractors
2265003022	4-Stroke Industrial Equipment	Aerial Lifts, Forklifts, Sweepers/Scrubbers, Other General Industrial Equipment, Other Material Handling Equipment, Terminal Tractors
2265003060	4-Stroke Industrial Equipment	ACRefrigeration
2267003022	LPG Industrial Equipment	Aerial Lifts, Forklifts, Sweepers/Scrubbers, Other General Industrial Equipment, Other Material Handling Equipment, Terminal Tractors
2268003022	CNG Industrial Equipment	Aerial Lifts, Forklifts, Sweepers/Scrubbers, Other General Industrial Equipment, Other Material Handling Equipment, Terminal Tractors
2268003060	CNG Industrial Equipment	ACRefrigeration
2270003022	Diesel Industrial Equipment	Aerial Lifts, Forklifts, Sweepers/Scrubbers, Other General Industrial Equipment, Other Material Handling Equipment, Terminal Tractors
2270003060	Diesel Industrial Equipment	ACRefrigeration

Table A-4. Nonroad Commercial Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2260006022	2-Stroke Commercial Equipment	Light Commercial Generator Sets, Pumps, Air Compressors, Gas Compressors, Welders, Pressure Washers, Hydro Power Units
2265006022	4-Stroke Commercial Equipment	Light Commercial Generator Sets, Pumps, Air Compressors, Gas Compressors, Welders, Pressure Washers, Hydro Power Units
2267006022	LPG Commercial Equipment	Light Commercial Generator Sets, Pumps, Air Compressors, Gas Compressors, Welders, Pressure Washers, Hydro Power Units
2268006022	CNG Commercial Equipment	Light Commercial Generator Sets, Pumps, Air Compressors, Gas Compressors, Welders, Pressure Washers, Hydro Power Units
2270006022	Diesel Commercial Equipment	Light Commercial Generator Sets, Pumps, Air Compressors, Gas Compressors, Welders, Pressure Washers, Hydro Power Units

Table A-5. Nonroad Lawn & Garden Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2260004020	2-Stroke Lawn & Garden Equipment (Residential)	Chain Saws < 6 HP
2260004021	2-Stroke Lawn & Garden Equipment (Commercial)	Chain Saws < 6 HP
2260004022	2-Stroke Lawn & Garden Equipment (Commercial)	Mowers, Tractors, Turf Equipment
2260004033	2-Stroke Lawn & Garden Equipment (Residential)	Lawn Mowers, Rotary Tillers < 6HP, Trimmers/Hedgers/Brush Cutters, Leafblowers/Vacuums, Rear Engine Riding Mowers, Front Mowers, Shredders < 6HP, Lawn & Garden Tractors, Wood Splitters, Chippers/Stump Grinders, Other Lawn & Garden Equipment
2260004035	2-Stroke Lawn & Garden Equipment (Residential)	Snowblowers
2260004036	2-Stroke Lawn & Garden Equipment (Commercial)	Snowblowers

Aggregated SCC	SCC Description	Equipment Types
2260004044	2-Stroke Lawn & Garden Equipment (Commercial)	Lawn Mowers, Rotary Tillers < 6HP, Trimmers/Hedgers/Brush Cutters, Leafblowers/Vacuums, Front Mowers, Shredders < 6HP, Wood Splitters, Chippers/Stump Grinders, Other Lawn & Garden Equipment
2265004022	4-Stroke Lawn & Garden Equipment (Commercial)	Mowers, Tractors, Turf Equipment
2265004033	4-Stroke Lawn & Garden Equipment (Residential)	Lawn Mowers, Rotary Tillers < 6HP, Trimmers/Hedgers/Brush Cutters, Leafblowers/Vacuums, Rear Engine Riding Mowers, Front Mowers, Shredders < 6HP, Lawn & Garden Tractors, Wood Splitters, Chippers/Stump Grinders, Other Lawn & Garden Equipment
2265004035	4-Stroke Lawn & Garden Equipment (Residential)	Snowblowers
2265004036	4-Stroke Lawn & Garden Equipment	Snowblowers
2265004044	4-Stroke Lawn & Garden Equipment (Commercial)	Lawn Mowers, Rotary Tillers < 6HP, Trimmers/Hedgers/Brush Cutters, Leafblowers/Vacuums, Front Mowers, Shredders < 6HP, Wood Splitters, Chippers/Stump Grinders, Other Lawn & Garden Equipment
2267004044	LPG Lawn & Garden Equipment (Commercial)	Lawn Mowers, Rotary Tillers < 6HP, Trimmers/Hedgers/Brush Cutters, Leafblowers/Vacuums, Front Mowers, Shredders < 6HP, Wood Splitters, Chippers/Stump Grinders, Other Lawn & Garden Equipment
2270004022	Diesel Lawn & Garden Equipment (Commercial)	Mowers, Tractors, Turf Equipment
2270004036	Diesel Lawn & Garden Equipment (Commercial)	Snowblowers
2270004044	Diesel Lawn & Garden Equipment (Commercial)	Lawn Mowers, Rotary Tillers < 6HP, Trimmers/Hedgers/Brush Cutters, Leafblowers/Vacuums, Front Mowers, Shredders < 6HP, Wood Splitters, Chippers/Stump Grinders, Other Lawn & Garden Equipment

Table A-6. Nonroad Recreational Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2260001020	2-Stroke Recreational Equipment	Snowmobiles
2260001022	2-Stroke Recreational Equipment	Off-Road Motorcycles and ATVs
2260001060	2-Stroke Recreational Equipment	Specialty Vehicles/Carts
2265001022	4-Stroke Recreational Equipment	Off-Road Motorcycles and ATVs
2265001050	4-Stroke Recreational Equipment	Golf Carts

Aggregated SCC	SCC Description	Equipment Types
2265001060	4-Stroke Recreational Equipment	Specialty Vehicles/Carts
2267001060	LPG Recreational Equipment	Specialty Vehicles/Carts
2270001060	Diesel Recreational Equipment	Specialty Vehicles/Carts

Table A-7. Nonroad Pleasure Craft SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2282005022	2-Stroke Pleasure Craft	Outboards, Personal Watercraft
2282010005	4-Stroke Inboards	4-Stroke Inboard/Sterndrive
2282020022	Diesel Pleasure Craft	Inboards, Outboards

Table A-8. Nonroad Logging Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2260007022	2-Stroke Logging Equipment	Chain Saws > 6HP, Shredders > 6HP, Skidders
2265007022	4-Stroke Logging Equipment	Chain Saws > 6HP, Shredders > 6HP, Skidders
2267007022	LPG Logging Equipment	Chain Saws > 6HP, Shredders > 6HP, Skidders
2268007022	CNG Logging Equipment	Chain Saws > 6HP, Shredders > 6HP, Skidders
2270007022	Diesel Logging Equipment	Chain Saws > 6HP, Shredders > 6HP, Skidders

Table A-9. Nonroad Railroad Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2285002015	Diesel Railroad Equipment	Diesel Railway Maintenance
2285004015	4-Stroke Railroad Equipment	4-Stroke Railway Maintenance
2285006015	LPG Railroad Equipment	LPG Railway Maintenance

Table A-10. Nonroad Underground Mining Equipment SCCs in the 2016v1 platform.

Aggregated SCC	SCC Description	Equipment Types
2270009010	Diesel Underground Mining Equipment	Other Underground Mining Equipment