February 12, 2019

SPECIFICATION SHEET: ONROAD_MEX

Description: Mexican Onroad (onroad_mex) emissions, for simulating 2016 and future year air quality

1. EXECUTIVE SUMMARY 1

2. INTRODUCTION 2

3. INVENTORY DEVELOPMENT METHODS 3

4. ANCILLARY DATA 4

Spatial Allocation 4

Temporal Allocation 5

Chemical Speciation 5

5. EMISSIONS PROJECTION METHODS 6

6. EMISSIONS PROCESSING REQUIREMENTS 6

7. EMISSIONS SUMMARIES 7

1. EXECUTIVE SUMMARY

Mexican onroad mobile source emissions are processed in the onroad_mex sector with inventories output from the MOVES-Mexico model. 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 Mexican onroad (onroad_mex) sector, which consists of all onroad mobile source emissions in Mexico. Emissions for this sector are based on the MOVES-Mexico model[1].

The SCCs in the MOVES-Mexico inventory follow the same pattern as the SCCs in the US onroad sector from SMOKE-MOVES. SCCs in the onroad_mex sector follow the format 220**FVV**0**RPP**, where:

- F = MOVES fuel type (1 for gasoline, 2 for diesel; no other fuel types in Mexico)
- VV = MOVES vehicle type (see Table 1)
- R = MOVES road type (1 for off-network, 2 for rural restricted, 3 for rural unrestricted, 4 for urban restricted, 5 for urban unrestricted)
- PP = SMOKE aggregate process. MOVES separately tracks over a dozen processes, but for computational reasons it is not practical to model all of these process separately. Instead, we use "aggregate" processes for SMOKE. MOVES process are mapped to SMOKE aggregate processes according to Table 2.

Some special considerations are:

- In Mexico, there are no emissions for MOVES vehicle types 41, 43, 51, or 54.
- In Mexico, emissions for extended idling are not modeled separately from aggregate process 72.

[1] ERG, 2017. "Technical Report: Development of Mexico Emission Inventories for the 2014 Modeling Platform." Available at ftp://newftp.epa.gov/air/emismod/2016/beta/reports/EPA%205-18%20Report_Clean%20Final_01042017.pdf

Table 1. MOVES vehicle 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

Table 2: SMOKE-MOVES aggregate processes

MOVES Process ID	Process description	SMOKE aggregate process
01	Running Exhaust	72
02	Start Exhaust	72
09	Brakewear	40
10	Tirewear	40
11	Evap Permeation	72
12	Evap Fuel Vapor Venting	72
13	Evap Fuel Leaks	72
15	Crankcase Running Exhaust	72
16	Crankcase Start Exhaust	72
17	Crankcase Extended Idle Exhaust	53
18	Refueling Displacement Vapor Loss	62
19	Refueling Spillage Loss	62
90	Extended Idle Exhaust	53
91	Auxiliary Power Exhaust	91

3. Inventory Development Methods

In support of prior emissions platforms, the MOVES-Mexico model was run for the years 2014 and 2017. For 2016 beta platform, emissions values from those two years were interpolated to year 2016 values as follows:

*2016 emissions = (2014 emissions + 2 * (2017 emissions)) / 3*

The MOVES-Mexico inventory includes emissions by county, SCC, and pollutant. The inventory includes emissions for individual species of NOX, PM2.5, and VOC. For VOC, individual species for both CB05 and CB6 are available. However, this is for the CB6-for-CAMx mechanism, not the CB6-for-CMAQ mechanism. For CMAQ modeling, this must be accounted for after SMOKE is run, as described in Section 6 of this document.

The raw inventories from MOVES-Mexico were not fully SMOKE-ready. The following post-processing steps were performed on MOVES-Mexico emissions inventories prior to running SMOKE:

- MOVES-Mexico outputs separate emissions for each MOVES process; these were aggregated to SMOKE aggregate process (see Table 2 above)
- Convert emissions for individual VOC species from units of moles to tons, using the same overall average molecular weight for each species that SMOKE uses when converting inventory emissions, which have to be in tons, back into moles
- Extra pollutants output by MOVES but not needed by SMOKE, such as total hydrocarbons, were removed

Combined, these steps reduce the size of the emissions inventory from over 15 gigabytes to around 6 gigabytes.

4. ANCILLARY DATA

Spatial Allocation

Spatial allocation of onroad_mex 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.

In Mexico, spatial surrogates for the 36US3 and 12US1 domains are unchanged from the 2011 emissions modeling platform, except for the incorporation of a new population surrogate based on 2015 population data.

Mexico onroad emissions are spatially allocated using three surrogates: 11 (2015 population – for all off-network emissions except commercial trucks), 22 (total road miles – for all on-network emissions), and 36 (commercial and industrial land – for off-network commercial trucks). Reports summarizing total emissions by spatial surrogate at the state and county level are included in the emissions modeling workgroup reports package. A national summary of emissions by spatial surrogate is in Table 3.

Table 3. Onroad_mex emissions by spatial surrogate (36US3 domain)

Surrogate	Description	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
11	MEX 2015 Population	1,385,774	0	281,317	2,116	1,873	533	291,992
22	MEX Total Road Miles	4,795,243	10,321	1,208,461	71,962	54,823	25,855	251,931
36	MEX Commercial plus Industrial Land	94,704	0	7,975	158	142	29	9,192

Temporal Allocation

The onroad_mex inventory from MOVES-Mexico is monthly and is temporalized in SMOKE to hourly using day-of-week and hour-of-day temporal profiles. Mexico daily and hourly profiles are based on national averages of US profiles from the 2014v1 platform. These average profiles are different for each vehicle type, and in the case of the diurnal profiles, are different for Saturday, Sunday, and all weekdays averaged together. A national summary of emissions by temporal profile is in Table 4.

Table 4. Onroad_mex emissions by temporal profile

Weekly profile	Diurnal profile[1]	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
MXON11	MXON11	643,410	1,338	27,726	1,169	732	1,371	50,672
MXON21	MXON21	2,491,627	4,203	443,992	8,458	4,223	7,728	239,800
MXON31	MXON31	2,574,547	3,597	491,498	7,639	4,095	7,873	214,835
MXON32	MXON32	90,952	127	17,006	268	143	271	7,662
MXON42	MXON42	189,092	175	84,945	7,365	6,119	1,362	12,294
MXON52	MXON52	225,415	398	101,235	13,819	11,571	2,079	17,735
MXON53	MXON53	11,262	24	5,652	852	710	115	958
MXON61	MXON61	23,166	151	91,563	10,183	8,603	1,687	3,424
MXON62	MXON62	59,058	357	241,447	24,913	20,987	4,108	8,183

[1] *There are different diurnal profiles for weekdays, Saturday, and Sunday. For example: MXON11MF (weekdays), MXON11S (Saturday), and MXON11X (Sunday).*

Chemical Speciation

The onroad_mex inventory includes individual model species of NOX, PM2.5, and VOC, so other than passing species through, it not necessary to perform any speciation within SMOKE itself, with two exceptions, as follows.

Individual PM species in the Mexico onroad inventory represent exhaust PM only, not brake and tire. Therefore, brake and tire PM (indicated by mode in the inventory) must still be speciated within SMOKE, which is done using the standard PM speciation profiles for brake and tire wear, respectively.

The Mexico onroad inventory includes emissions for individual model species for the CB05 and CB6 mechanisms. However, this CB6 speciation mechanism is for CAMx, not CMAQ, and does not include the additional species needed for CB6 within CMAQ. CMAQ uses a newer version of the CB6 mechanism, in which the XYL species is replaced with XYLMN and NAPH, and includes an additional tracer called SOAALK. The Mexico inventory includes XYL, and also naphthalene emissions under pollutant code 91203. After the SMOKE run is complete, similar to the US onroad sector, an extra step is needed to convert the emissions from CB6-CAMx to CB6-CMAQ. To do this, we apply three formulas:

- NAPH comes from inventory HAP 91203
- XYLMN = XYL – 0.966*NAPH (the 0.966 accounts for differences in molecular weights)
- SOAALK = 0.108*PAR (create SOAALK as a function of PAR)

This conversion is performed on using a program called combine. All CB6-CAMx model species except for XYL are carried forward as-is during the conversion to CB6-CMAQ.

The Mexico onroad inventory also includes several VOC HAPs which play a role in VOC speciation within MOVES-Mexico. Other than naphthalene, it is not necessary to include these extra HAPs in modeling, although acrolein and 1,3-butadiene are typically included in EPA emissions in support of CMAQ multipollutant “lite” modeling.

5. Emissions Projection Methods

MOVES-Mexico was run to create emissions inventories for years 2023 and 2028. Results from those runs are used in future year emissions processing for beta platform. The same inventory post-processing steps that are described in Section 3 apply for the future year inventories. These emissions are unchanged from the 2011 platform.

6. Emissions Processing Requirements

Onroad_mex sector emissions were processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE[2]) modeling system. Unlike the US onroad sector, SMOKE-MOVES is not run for Mexico. Instead, the monthly inventories were processed through SMOKE as a routine area source inventory.

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

The onroad_mex sector inventory is monthly, and was run through Smkinven 12 times, each with a different SMKINVEN_MONTH setting. Emissions are processed for seven representative days per month (one for each day of the week). Holiday-specific temporalization is not performed in Mexico. After SMOKE is run for CB6-CAMx, the emissions are converted to CB6-CMAQ as described in Section 4, Chemical Speciation. This is a 2-D sector in which all emissions are 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. Plots and maps are available online through the LADCO website[3] and the Intermountain West Data Warehouse[4].

The case descriptions are as follows:

2011en, 2023en, 2028el = Final 2011, 2023, and 2028 cases from the 2011v6.3 platform

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

Table 5. Comparison of Mexico national total annual CAPS onroad_mex emissions (tons/yr)

Pollutant	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
CO	5,887,937	6,300,798	6,308,529	6,308,529	6,088,942		5,528,091	
NH3	9,170	9,891	10,370	10,370	12,143		13,875	
NOX	1,411,830	1,473,456	1,505,063	1,505,063	1,454,958		1,343,254	
PM10	57,782	68,820	74,664	74,664	95,083		109,609	
PM2.5	43,576	52,604	57,183	57,183	73,023		83,911	
SO2	22,470	24,942	26,594	26,594	32,073		36,329	
VOC	541,390	554,777	555,564	555,564	562,919		577,329	

Table 6. Comparison of state total annual NOx onroad_mex emissions (tons/yr)

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Aguascalientes	18,716	19,669	20,215	20,215	19,700		18,161	
Baja Calif	74,570	78,087	79,948	79,948	77,577		71,412	
Baja Calif Sur	19,961	20,918	21,442	21,442	20,750		19,010	
Campeche	9,367	9,856	10,134	10,134	9,834		8,984	
Chiapas	23,295	24,458	25,101	25,101	24,325		22,274	
Chihuahua	76,676	80,450	82,625	82,625	80,295		73,835	

[3] https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/
[4] http://views.cira.colostate.edu/iwdw/eibrowser2016

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Coahuila	38,217	40,208	41,371	41,371	40,294		37,017	
Colima	11,485	12,071	12,400	12,400	12,026		10,999	
Distrito Federal	143,350	146,063	145,465	145,465	138,120		131,486	
Durango	24,238	25,384	26,004	26,004	25,168		23,099	
Guanajuato	57,800	60,746	62,437	62,437	60,848		56,088	
Guerrero	28,815	30,306	31,142	31,142	30,232		27,670	
Hidalgo	34,009	35,706	36,671	36,671	35,730		32,989	
Jalisco	122,360	127,324	129,900	129,900	125,191		115,550	
Mexico	102,556	106,129	107,698	107,698	103,470		96,286	
Michoacan	68,641	71,987	73,805	73,805	71,574		65,771	
Morelos	19,926	20,955	21,551	21,551	20,997		19,316	
Nayarit	13,702	14,402	14,795	14,795	14,352		13,133	
Nuevo Leon	86,518	89,373	90,750	90,750	86,734		80,130	
Oaxaca	26,792	28,017	28,709	28,709	27,781		25,528	
Puebla	49,244	51,663	52,956	52,956	51,425		47,339	
Queretaro	20,361	21,359	21,930	21,930	21,327		19,647	
Quintana Roo	13,672	14,408	14,847	14,847	14,466		13,247	
San Luis Potosi	32,362	34,052	35,041	35,041	34,138		31,366	
Sinaloa	46,984	49,259	50,517	50,517	48,875		44,709	
Sonora	46,289	48,513	49,733	49,733	48,130		44,090	
Tabasco	17,304	18,198	18,700	18,700	18,148		16,602	
Tamaulipas	58,506	61,450	63,089	63,089	61,170		56,009	
Tlaxcala	8,901	9,346	9,598	9,598	9,355		8,643	
Veracruz	68,186	71,632	73,641	73,641	71,617		65,768	
Yucatan	20,606	21,706	22,361	22,361	21,783		19,957	
Zacatecas	28,420	29,762	30,487	30,487	29,527		27,135	

Table 7. Comparison of state total annual VOC onroad_mex emissions (tons/yr)

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Aguascalientes	7,126	7,232	7,227	7,227	7,314		7,543	
Baja Calif	25,233	26,104	26,079	26,079	26,025		26,014	
Baja Calif Sur	6,999	7,269	7,290	7,290	7,340		7,388	
Campeche	3,948	4,094	4,104	4,104	4,122		4,148	
Chiapas	9,109	9,455	9,480	9,480	9,519		9,566	
Chihuahua	26,460	26,850	26,832	26,832	27,193		28,098	
Coahuila	15,532	15,791	15,816	15,816	16,135		16,760	
Colima	4,735	4,923	4,946	4,946	5,004		5,063	
Distrito Federal	60,134	60,297	60,075	60,075	60,474		62,749	
Durango	8,817	9,176	9,219	9,219	9,370		9,508	
Guanajuato	22,563	22,958	22,991	22,991	23,431		24,282	
Guerrero	12,770	13,308	13,401	13,401	13,669		13,920	
Hidalgo	12,794	12,980	12,962	12,962	13,110		13,515	
Jalisco	45,893	46,480	46,491	46,491	47,241		49,156	
Mexico	38,111	39,080	38,912	38,912	38,793		39,168	

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Michoacan	27,435	28,614	28,799	28,799	29,395		29,898	
Morelos	7,929	8,076	8,099	8,099	8,274		8,593	
Nayarit	5,947	6,205	6,255	6,255	6,409		6,550	
Nuevo Leon	34,033	35,032	35,132	35,132	35,793		36,993	
Oaxaca	8,496	8,566	8,544	8,544	8,625		8,949	
Puebla	18,745	19,551	19,649	19,649	19,950		20,145	
Queretaro	6,963	7,071	7,068	7,068	7,164		7,396	
Quintana Roo	5,594	5,673	5,673	5,673	5,739		5,928	
San Luis Potosi	13,518	13,776	13,828	13,828	14,187		14,792	
Sinaloa	17,555	18,307	18,445	18,445	18,869		19,251	
Sonora	17,094	17,817	17,929	17,929	18,303		18,630	
Tabasco	7,343	7,633	7,668	7,668	7,754		7,840	
Tamaulipas	24,360	25,333	25,464	25,464	25,872		26,277	
Tlaxcala	3,266	3,309	3,297	3,297	3,321		3,412	
Veracruz	24,046	24,394	24,388	24,388	24,651		25,414	
Yucatan	8,431	8,571	8,588	8,588	8,745		9,073	
Zacatecas	10,411	10,854	10,915	10,915	11,130		11,309	