

March 7, 2019

## **SPECIFICATION SHEET: ONROAD\_MEX**

Description: Mexican Onroad (onroad\_mex) emissions, for simulating 2016 air quality

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### **1. EXECUTIVE SUMMARY**

Mexican onroad mobile source emissions are processed in the onroad\_mex sector with inventories output from the MOVES-Mexico model. Base 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<sup>1</sup>.

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 220FVVORPP, 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.

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<sup>1</sup> 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](ftp://newftp.epa.gov/air/emismod/2016/beta/reports/EPA%205-18%20Report_Clean%20Final_01042017.pdf)

**Table 1. MOVES vehicle types**

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

**Table 2: SMOKE-MOVES aggregate processes**

<b>MOVES Process ID</b>	<b>Process description</b>	<b>SMOKE aggregate process</b>
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:

$$2016 \text{ emissions} = (2014 \text{ emissions} + 2 * (2017 \text{ emissions})) / 3$$

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 <sup>1</sup>	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

<sup>1</sup> 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**

Future year projections for the 2016 beta platform have not yet been finalized at the time this was written.

## **6. EMISSIONS PROCESSING REQUIREMENTS**

Onroad\_mex sector emissions were processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE<sup>2</sup>) 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.

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

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<sup>2</sup> <http://www.smoke-model.org/index.cfm>

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<sup>3</sup> and the Intermountain West Data Warehouse<sup>4</sup>.

The case descriptions are as follows:

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

2014fd = 2014NElv2 and 2014 NATA

2016fe = 2016 alpha platform (grown from 2014NElv2)

2016ff = 2016 beta platform

**Table 5. Comparison of Mexico national total annual CAPS onroad\_mex emissions (tons/yr)**

Pollutant	2011en	2014fd	2016fe	2016ff	2023en	2028el
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	2028el
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
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

<sup>3</sup> <https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/>

<sup>4</sup> <http://views.cira.colostate.edu/iwdw/eibrowser2016>

State	2011en	2014fd	2016fe	2016ff	2023en	2028el
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	2028el
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
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



<b>State</b>	<b>2011en</b>	<b>2014fd</b>	<b>2016fe</b>	<b>2016ff</b>	<b>2023en</b>	<b>2028el</b>
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