

March 7, 2019

## **SPECIFICATION SHEET: ONROAD\_CAN**

Description: Canadian Onroad (onroad\_can) emissions, for simulating 2016 air quality

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### **1. EXECUTIVE SUMMARY**

Canadian onroad mobile source emissions are processed in the onroad\_can sector using an inventory provided by Environment and Climate Change Canada (ECCC) for year 2015. Temporal profiles and spatial allocation are also provided by ECCC. 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 province-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 Canadian onroad (onroad\_can) sector, which consists of all onroad mobile source emissions in Canada. Emissions for this sector were provided by ECCC for the year 2015, and were used directly (i.e. without projecting) for 2016 modeling.

A list of all SCCs in the onroad\_can sector is provided in Table 1. ECCC onroad inventories use SCCs consistent with older MOBILE6 modeling, as opposed to SCCs consistent with SMOKE-MOVES modeling.

**Table 1: SCCs in the onroad\_can sector**

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2201000062	Mobile Sources	Highway Vehicles - Gasoline	Refueling	Total Spillage and Displacement
2201001000	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Vehicles (LDGV)	Total: All Road Types
2201001110	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Vehicles (LDGV)	Rural Interstate: Total
2201001130	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Vehicles (LDGV)	Rural Other Principal Arterial: Total
2201001230	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Vehicles (LDGV)	Urban Interstate: Total
2201001270	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Vehicles (LDGV)	Urban Other Principal Arterial: Total
2201040000	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Trucks 3 & 4 (M6) = LDGT2 (M5)	Total: All Road Types
2201040110	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Trucks 3 & 4 (M6) = LDGT2 (M5)	Rural Interstate: Total
2201040130	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Trucks 3 & 4 (M6) = LDGT2 (M5)	Rural Other Principal Arterial: Total
2201040230	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Trucks 3 & 4 (M6) = LDGT2 (M5)	Urban Interstate: Total
2201040270	Mobile Sources	Highway Vehicles - Gasoline	Light Duty Gasoline Trucks 3 & 4 (M6) = LDGT2 (M5)	Urban Other Principal Arterial: Total

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2201070000	Mobile Sources	Highway Vehicles - Gasoline	Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV)	Total: All Road Types
2201070110	Mobile Sources	Highway Vehicles - Gasoline	Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV)	Rural Interstate: Total
2201070130	Mobile Sources	Highway Vehicles - Gasoline	Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV)	Rural Other Principal Arterial: Total
2201070230	Mobile Sources	Highway Vehicles - Gasoline	Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV)	Urban Interstate: Total
2201070270	Mobile Sources	Highway Vehicles - Gasoline	Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV)	Urban Other Principal Arterial: Total
2201080000	Mobile Sources	Highway Vehicles - Gasoline	Motorcycles (MC)	Total: All Road Types
2201080110	Mobile Sources	Highway Vehicles - Gasoline	Motorcycles (MC)	Rural Interstate: Total
2201080130	Mobile Sources	Highway Vehicles - Gasoline	Motorcycles (MC)	Rural Other Principal Arterial: Total
2201080230	Mobile Sources	Highway Vehicles - Gasoline	Motorcycles (MC)	Urban Interstate: Total
2201080270	Mobile Sources	Highway Vehicles - Gasoline	Motorcycles (MC)	Urban Other Principal Arterial: Total
2202000062	Mobile Sources	Highway Vehicles - Diesel	Refueling	Total Spillage and Displacement
2203000062	Mobile Sources	Highway Vehicles - Compressed Natural Gas (CNG)	Refueling	Total Spillage and Displacement
2204000062	Mobile Sources	Highway Vehicles - Liquefied Petroleum Gas (LPG)	Refueling	Total Spillage and Displacement
2230001000	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Vehicles (LDDV)	Total: All Road Types
2230001110	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Vehicles (LDDV)	Rural Interstate: Total

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2230001130	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Vehicles (LDDV)	Rural Other Principal Arterial: Total
2230001230	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Vehicles (LDDV)	Urban Interstate: Total
2230001270	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Vehicles (LDDV)	Urban Other Principal Arterial: Total
2230060000	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT)	Total: All Road Types
2230060110	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT)	Rural Interstate: Total
2230060130	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT)	Rural Other Principal Arterial: Total
2230060230	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT)	Urban Interstate: Total
2230060270	Mobile Sources	Highway Vehicles - Diesel	Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT)	Urban Other Principal Arterial: Total
2230070000	Mobile Sources	Highway Vehicles - Diesel	All HDDV including Buses (use subdivisions -071 thru -075 if possible)	Total: All Road Types
2230070110	Mobile Sources	Highway Vehicles - Diesel	All HDDV including Buses (use subdivisions -071 thru -075 if possible)	Rural Interstate: Total
2230070130	Mobile Sources	Highway Vehicles - Diesel	All HDDV including Buses (use subdivisions -071 thru -075 if possible)	Rural Other Principal Arterial: Total
2230070230	Mobile Sources	Highway Vehicles - Diesel	All HDDV including Buses (use subdivisions -071 thru -075 if possible)	Urban Interstate: Total
2230070270	Mobile Sources	Highway Vehicles - Diesel	All HDDV including Buses (use subdivisions -071 thru -075 if possible)	Urban Other Principal Arterial: Total

### **3. INVENTORY DEVELOPMENT METHODS**

ECCC provided the Canadian onroad emissions inventory for 2015 in a format that is close to, but not exactly, Flat File 2010 (FF10). Some columns that are unused by SMOKE contained metadata that needed to be reformatted or moved prior to importing the data into EPA's Emissions Modeling Framework (EMF), due to restrictions on variable types imposed by the FF10 format (e.g. character values in numeric fields).

The onroad\_can emissions inventory includes monthly emissions. Emissions for year 2015 were used directly for year 2016 modeling in beta platform.

The Canada onroad inventory is province-level in most provinces, with the exception of Ontario and British Columbia. In Ontario, inventory emissions are placed in one of four regions; British Columbia has two regions. Each region has a separate set of spatial surrogates.

Detailed documentation of the ECCC emissions inventories for 2015 is provided in Documentation for SMOKE-Ready 2015 Air Pollutant Emission Inventory (APEI) Package version 1 (ECCC, 2018).<sup>1</sup> The onroad\_can sector includes two inventories, both under the transportation category: OnRoad, and OnRoad Refueling.

### **4. ANCILLARY DATA**

#### **Spatial Allocation**

Spatial allocation of onroad\_can 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. For development of spatial surrogates, ECCC did not provide spatial surrogates directly, but instead provided Shapefiles and specification files for running the Surrogate Tool. Using those inputs, EPA ran the Surrogate Tool to create Canadian spatial surrogates for the 36US3 and 12US1 grids.

ECCC provided a cross-reference for mapping SCCs to their surrogates. The onroad\_can sector uses surrogates based on total road miles and population, and which include sub-province FIPS codes in Ontario and British Columbia consistent with the onroad inventory.

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

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<sup>1</sup> ECCC 2018. Documentation for SMOKE-Ready 2015 Air Pollutant Emission Inventory (APEI) Package version 1. Available from [ftp://newftp.epa.gov/air/emismod/2016/beta/reports/A18031\\_2015\\_Canadian\\_CAC\\_EmissionsInventoryPackage\\_version1.pdf](ftp://newftp.epa.gov/air/emismod/2016/beta/reports/A18031_2015_Canadian_CAC_EmissionsInventoryPackage_version1.pdf)

emissions by spatial surrogate is in Table 2. Note that Canadian surrogate codes are not consistent with US surrogate codes.

**Table 2. Onroad\_can emissions by spatial surrogate (36US3 grid)**

Surrogate	Description	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
200	CAN Urban Primary Road Miles	249,797	1,619	85,558	4,324	2,851	329	8,396
210	CAN Rural Primary Road Miles	107,107	683	51,307	2,243	1,673	139	3,807
220	CAN Urban Secondary Road Miles	439,741	3,021	136,582	12,806	5,708	690	22,374
230	CAN Rural Secondary Road Miles	244,062	1,769	96,911	5,493	3,238	374	10,370
240	CAN Total Road Miles	691,587	43	57,401	1,521	1,355	77	103,658

### Temporal Allocation

The onroad\_can inventory is monthly and is temporalized to hourly within SMOKE using day-of-week and hour-of-day temporal profiles. ECCC provided temporal profiles and an SCC cross-reference. The Canadian temporal profiles used in beta platform differ from those provided by ECCC in the following ways:

- ECCC provided temporal profiles and cross-references in a format used by older versions of SMOKE (3.5 and earlier). We converted their profiles and cross-reference to the format used by SMOKE 4.6.
- ECCC's cross-reference included an overall default profile (SCC=000000000) to be used when specific SCCs were not included in the cross-reference. As a standard practice, we do not include an overall default profile in our temporal cross-reference, so we removed that assignment and filled in missing SCCs, with profiles assigned to those for similar SCCs as needed.

Reports summarizing total emissions according to the 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 summary of emissions by temporal profile is in Table 3.

**Table 3. Onroad\_can emissions by temporal profile**

Weekly profile	Diurnal profile <sup>1</sup>	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
2002	2013	558,967	0	37,302	1,115	987	70	91,338
20021	2001	68,057	524	7,576	382	184	93	1,629
20021	2002	143,294	1,454	19,409	1,767	484	275	4,956
20021	2013	6,696	0	352	6	5	0	1,736
20022	2014	139,984	475	121,406	5,593	4,249	145	7,602
20031	2007	166,180	1,357	18,617	1,311	524	244	4,309

<b>20031</b>	<b>2009</b>	272,355	2,600	31,215	6,032	1,236	544	11,470
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<sup>1</sup> There are different diurnal profiles for weekdays and weekends; for example, 2001wd and 2001we.

### Chemical Speciation

The onroad\_can sector includes speciation of PM2.5 and VOC emissions using the same profiles and SCC cross-references as in the US. No HAPs are included in the inventory, and so there is no HAP integration in this sector. Both PM and VOC are specified by mode: exhaust, brake, and tire for PM, and exhaust and evaporative for VOC.

New to beta 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 4. 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.

Reports summarizing total PM2.5 and VOC emissions according to speciation profile are included in the emissions modeling workgroup reports package at the state and county level.

**Table 4: Ethanol percentages by volume by Canadian province**

<b>Province</b>	<b>Ethanol % by volume (E10 = 10%)</b>
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%

## 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\_can sector emissions are processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE<sup>2</sup>) modeling system. The onroad\_can sector inventory is monthly, and is 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 Canada. This is a 2-D sector in which all emissions are output to a single layer gridded emissions file.

## 7. EMISSIONS SUMMARIES

National and province 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 Canada national total annual CAPS onroad\_can emissions (tons/yr)**

Pollutant	2011en	2014fd	2016fe	2016ff	2023en	2028el
CO	2,259,190	2,259,190	2,015,448	1,732,778	1,284,220	1,357,020
NH3	8,884	8,884	8,511	7,139	7,390	15,542
NOX	505,059	505,059	438,679	428,196	239,542	127,001
PM10	29,840	29,840	26,335	26,407	15,822	12,545
PM2.5	22,772	22,772	19,225	14,839	8,583	5,865
SO2	1,673	1,673	1,441	1,609	745	1,553
VOC	205,535	205,535	172,449	148,637	73,190	69,550

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

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

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



**Table 6. Comparison of province total annual NOx onroad\_can emissions (tons/yr)**

Province	2011en	2014fd	2016fe	2016ff	2023en	2028el
Alberta	108,703	108,703	98,853	99,058	69,301	23,966
British Columbia	64,498	64,498	56,105	65,803	30,926	15,691
Manitoba	28,630	28,630	25,343	18,380	15,482	7,033
NW Territories	1,215	1,215	1,070	2,476	632	198
New Brunswick	12,978	12,978	10,970	9,585	4,945	5,021
Newfoundland	6,054	6,054	5,193	5,885	2,611	1,972
Nova Scotia	10,626	10,626	9,015	9,480	4,183	3,516
Nunavut	0	0	0	0	0	36
Ontario	133,818	133,818	112,822	104,876	49,835	30,246
Prince Edward Island	2,985	2,985	2,513	2,124	1,100	878
Quebec	94,288	94,288	79,010	75,529	33,176	27,744
Saskatchewan	39,296	39,296	36,059	34,527	26,347	10,537
Yukon	1,969	1,969	1,727	474	1,004	162

**Table 7. Comparison of province total annual VOC onroad\_can emissions (tons/yr)**

Province	2011en	2014fd	2016fe	2016ff	2023en	2028el
Alberta	38,108	38,108	32,445	28,148	15,453	12,427
British Columbia	29,932	29,932	25,145	25,326	10,786	11,626
Manitoba	16,257	16,257	13,582	8,126	5,558	3,662
NW Territories	454	454	376	279	142	107
New Brunswick	4,956	4,956	4,111	3,043	1,576	2,043
Newfoundland	2,439	2,439	2,034	1,558	818	863
Nova Scotia	4,560	4,560	3,767	3,041	1,385	1,748
Nunavut	0	0	0	0	0	25
Ontario	58,001	58,001	48,370	40,692	19,480	16,951
Prince Edward Island	980	980	810	729	300	368
Quebec	33,137	33,137	27,581	24,413	10,911	13,353
Saskatchewan	16,126	16,126	13,749	13,202	6,618	6,254
Yukon	585	585	479	80	161	122