ENVIRON ALPINE GEOPHYSICS UNC INSTITUTE FOR THE ENVIRONMENT

March 12, 2013

TECHNICAL MEMORANDUM No. 11: CANADA AND MEXICO EMISSIONS

To: Tom Moore, Western Regional Air Partnership (WRAP)

From: Zac Adelman, University of North Carolina/Institute for the Environment
Ralph Morris, ENVIRON International Corporation
Cyndi Loomis, Alpine Geophysics, LLC

Subject: Emissions from Canada and Mexico for the WestJumpAQMS 2008 Photochemical Modeling

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INTRODUCTION

ENVIRON International Corporation (ENVIRON), Alpine Geophysics, LLC (Alpine) and the University of North Carolina (UNC) at Chapel Hill Institute for Environment are performing the West-wide Jump Start Air Quality Modeling Study (WestJumpAQMS) managed by the Western Governors' Association (WGA) for the Western Regional Air Partnership (WRAP). WestJumpAQMS is setting up the CAMx photochemical grid model for the 2008 calendar year (plus spin up days for the end of December 2007) on a 36 km CONUS, 12 km WESTUS and several 4 km Inter-Mountain West domains. The WestJumpAQMS Team are currently compiling emissions to be used for the 2008 base case modeling, with the 2008 National Emissions Inventory (NEI) being a major data source, and are preparing 13 Technical Memorandums discussing the sources of the 2008 emissions by major source sector:

1. Point Sources including Electrical Generating Units (EGUs) and Non-EGUs;
2. Non-Point (Area) plus Non-Road Mobile Sources;
3. On-Road Mobile Sources that will be based on MOVES;
4. Oil and Gas Sources (5 installments);
5. Fires Emissions including wildfire, prescribed burns and agricultural burning;
6. Fugitive Dust Sources;
7. Off-Shore Shipping Sources;
8. Ammonia Emissions;
9. Biogenic Emissions;

10. Eastern USA Emissions (superseded);
11. Mexico/Canada;
12. Sea Salt and Lightning Emissions; and
13. Emissions Modeling Parameters including spatial surrogates, temporal adjustment parameters and chemical (VOC and PM) speciation profiles.

This document is draft Technical Memo Number 11 that discusses the approach and data sources to be used for developing emissions for Canada and Mexico for the WestJumpAQMS 2008 base case emissions scenario.

CANADA EMISSIONS

The WestJumpAQMS 2008 base case emissions for Canada are based on a 2006 emissions inventory from Environment Canada (EC). This national inventory contains provincial-level emissions for all source categories. The EC 2006 inventory is based on Canada's National Pollutant Release Inventory (NPRI[1]) for 2006. The database files are in Sparse Matrix Operator Kernel Emissions (SMOKE) One Record per Line (ORL) format. The database provides annual emissions of seven criteria air pollutants (CAPs): VOC, CO, NO_x, PM_{10}, $PM_{2.5}$, SO_2, and NH_3 for all of Canada. The EC 2006 CAP stationary point source inventory includes a separate file for speciated VOC emissions (Carbon Bond CB05 chemical species). The EC inventory also includes stationary area, mobile and upstream oil and gas point source emissions data. Although emissions reported to NPRI could overestimate typical emissions, as they include upset and accidental releases, the EC inventory is considered the most updated Canadian national inventory. EC applied a fugitive dust transport factor (FDTF) to account for fugitive dust emissions that are deposited locally and so are not transported downwind. More specifically, particulate matter (PM) dust emissions for road dust, construction and agriculture were reduced by 75% in the EC 2006 emissions inventory (i.e., a 0.25 FDTF).

The EC 2006 inventory is based on the NPRI inventory so the documentation is on the NPRI website[1] which also has summary emissions for all of Canada[2]. The EC 2006 emissions inventory was processed by the SMOKE emissions model in three batches: (1) elevated point source; (2) on-road mobile sources; and (3) area sources, which also included non-road mobile sources. Temporal allocation of the annual EC inventory to month, day-of-week and hour-of-day used U.S. EPA profiles and assignments by inventory Source Classification Codes (SCC). Spatial aggregation of the Provincial area and mobile sources to the 36/12/4 km modeling domains was also based on SCCs using spatial surrogate distributions from the EC. Chemical speciation for the area and mobile sources was also based on SCCs. However, as noted above, the Canadian point sources in the EC 2006 emissions database were already speciated into the CB05 chemical species used by the photochemical grid models (PGMs).

1 http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1
2 http://www.ec.gc.ca/pdb/websol/emissions/2006/2006_canada_e.cfm

Many of the Canadian point sources were classified using the same miscellaneous SCC code in order to keep the confidentiality of the process of the point source. This makes it difficult to isolate specific types of point sources (e.g., coal-fired power plants) and results in the application of flat temporal allocation profiles (i.e. the emissions don't change from month-to-month, day-to-day, or hour-to-hour) .

Canadian Emissions Modeling Results

As noted above, the Canadian point, mobile and area source emissions were processed separately by SMOKE. Figure 1 displays the WestJumpAQMS 36 km continental U.S. (CONUS), 12 km western U.S. (WESTUS) and 4 km intermountain-west domain (IMWD) modeling domains for which photochemical grid model (PGM) emissions and meteorological inputs were developed. Because each of the three domains includes portions of Canada, the EC 2006 emissions inventory was processed separately by SMOKE for the 36, 12 and 4 km domains. Because the 36 km CONUS domain contains the largest amount of Canada, we present the Canadian emissions results for just the 36 km CONUS results noting that the results for the 12 and 4 km domains would be a subset of the 36 km domain results.

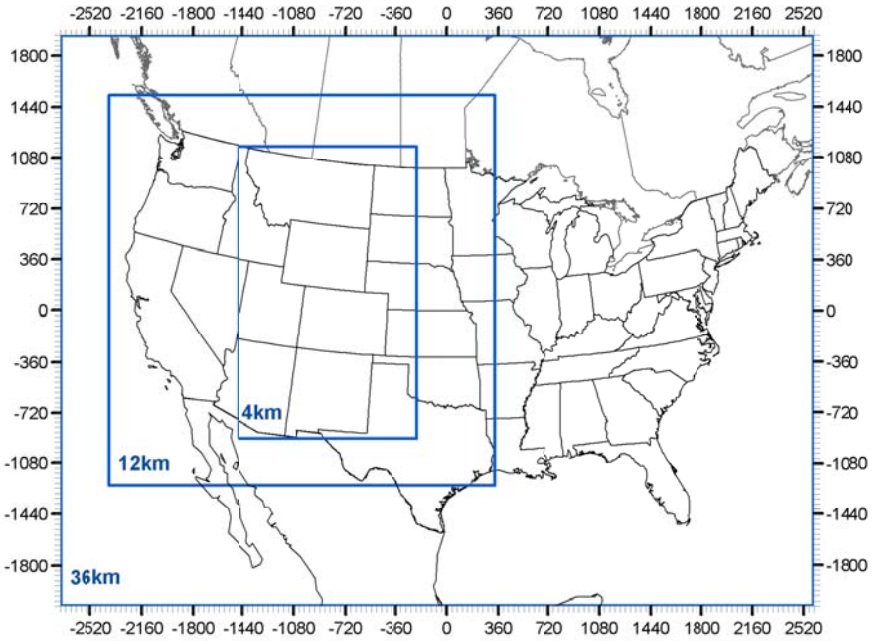

Figure 1. 36 km CONUS, 12 km WESTUS and 4 km IMWD modeling domains used for developing PGM emission inputs in WestJumpAQMS.

Canadian Point Source Emissions

Table 1 summarizes the EC 2006 inventory point source emissions by Province with the relative contributions of the Province emissions to the total given in Figure 2. Alberta has the most point source NO_X emissions (62%), followed by Ontario (15%), Saskatchewan (8%) and Quebec (6%). Almost all of the point source VOC emissions come from Saskatchewan (52%) and Alberta (45%), presumably due to largest amounts of oil and gas development in these two Provinces. SO_2 emissions are more evenly distributed across the Provinces with Ontario having the most (29%) followed by Manitoba (26%), Alberta (20%), Quebec (11%) and Saskatchewan (8%). SO_2 emissions are typically dominated by coal-fired electricity generation; however since the EC 2006 point source inventory SCC codes are mostly undefined this could not be confirmed. Fine particulate ($PM_{2.5}$) is also pretty evenly distributed across the Provinces, with Ontario having the most (28%) followed by Quebec (19%), Alberta (18%) and British Columbia (17%). As noted previously, to protect confidentiality generic SCC codes are used for point sources in the EC 2006 emissions inventory. Thus, we do not have information on the processes (e.g., coal-fired electricity generation, oil and gas development, etc.) that produced the emissions.

Table 1. Summary of EC 2006 Canadian point source emissions (tons per day) in the 36 km CONUS domain by Province.

Region Number	Province	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
110000	Newfoundland	20	18	0	0	12	11	4	8
111000	Prince Edward Is.	0	1	0	0	3	0	0	0
112000	Nova Scotia	3	15	0	0	42	4	2	2
113000	New Brunswick	84	67	0	1	156	12	7	5
124000	Quebec	1,084	133	0	3	501	54	36	19
135000	Ontario	474	355	5	19	1,303	85	53	33
146000	Manitoba	19	19	26	4	1,174	17	9	8
147000	Saskatchewan	122	192	640	3	363	21	12	9
148000	Alberta	1,082	1,470	553	25	911	51	34	17
159000	British Columbia	593	80	2	5	95	64	31	33
	Total	3,481	2,350	1,226	58	4,559	321	188	134

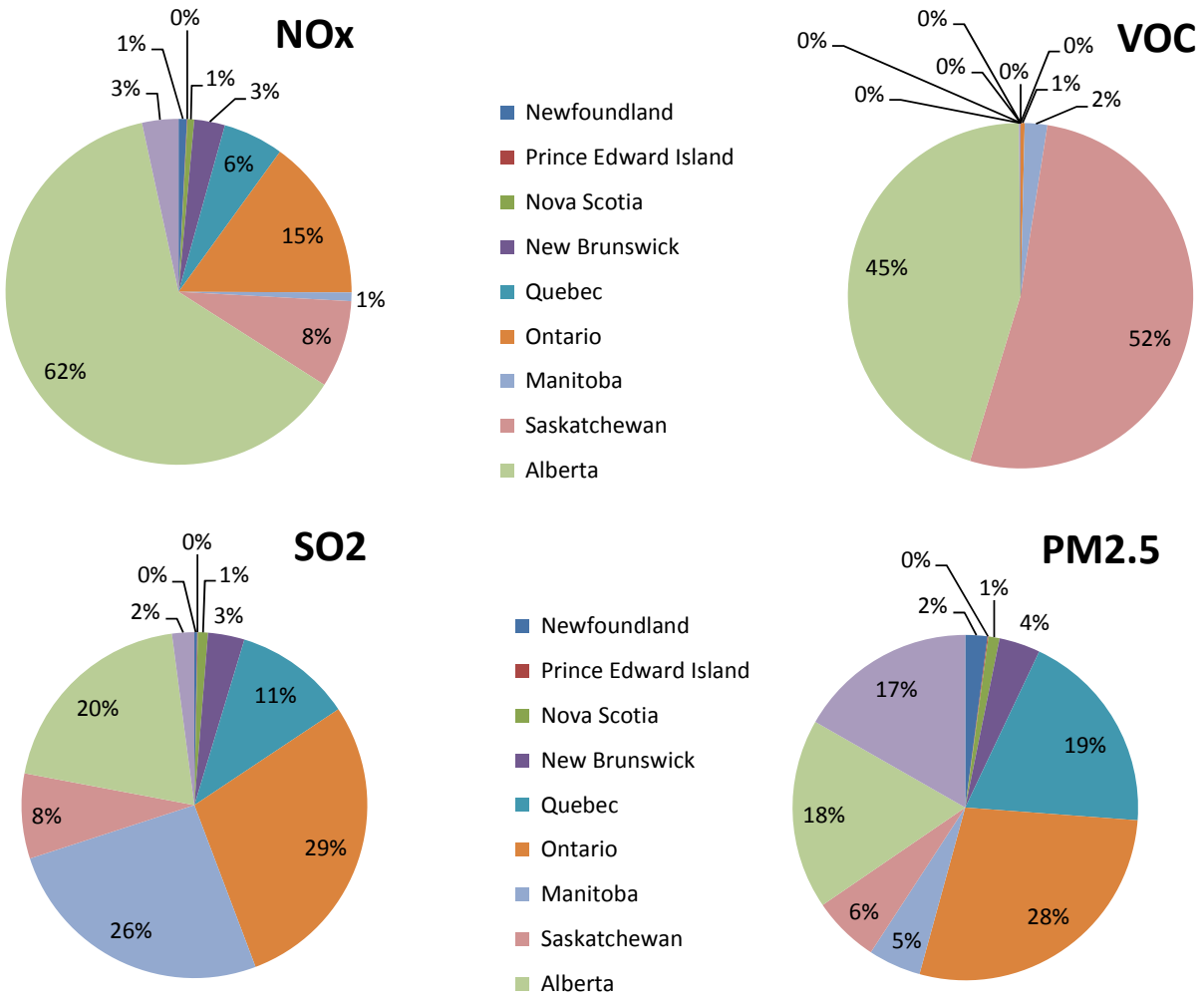

Figure 2. Relative contributions of NO_X, VOC, SO_2 and $PM_{2.5}$ EC 2006 emissions by Province to total point source emissions within the Canadian portion of the 36 km CONUS domain.

Canada On-Road Mobile Source Emissions

A summary of the EC 2006 on-road mobile source emissions in the Canadian portion of the 36 km CONUS domain by Province is given in Table 2 and Figure 3. There is consistency in the relative contributions of different pollutants across Provinces for on-road mobile sources. The on-road mobile source emissions contribution will depend on the number vehicles, vehicle types and the length of their trips. Thus, it is not surprising that Ontario Province has the highest on-road mobile source emissions contribution (24-28%) since it has the highest population. Quebec is the Province with the second highest population and it has the second highest contribution to mobile source emissions (22-24%). Although British Columbia has approximately 20% more people than Alberta, Alberta has higher contribution to Canada on-road mobile sources (17-18%) than British Columbia (11-14%). Presumably this is due to more people driving longer trips, use of higher polluting vehicles (e.g., trucks) and possible more heavy duty truck traffic.

Table 2. Summary of EC 2006 Canadian on-road mobile source emissions (tons per day) in the 36 km CONUS domain by Province.

Region Number	Province	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
110000	Newfoundland	2	0	0	0	0	0	0	0
111000	Prince Edward Is.	66	8	4	0	0	0	0	0
112000	Nova Scotia	255	29	15	1	0	1	1	0
113000	New Brunswick	404	57	25	2	1	1	1	0
124000	Quebec	2,677	318	160	14	3	10	7	3
135000	Ontario	3,321	401	178	23	4	11	7	4
146000	Manitoba	718	80	46	2	1	2	2	1
147000	Saskatchewan	1,094	116	76	2	1	3	2	1
148000	Alberta	2,060	253	132	7	2	7	5	2
159000	British Columbia	1,468	175	106	7	2	5	3	1
	Total	12,065	1,438	742	58	15	40	28	12

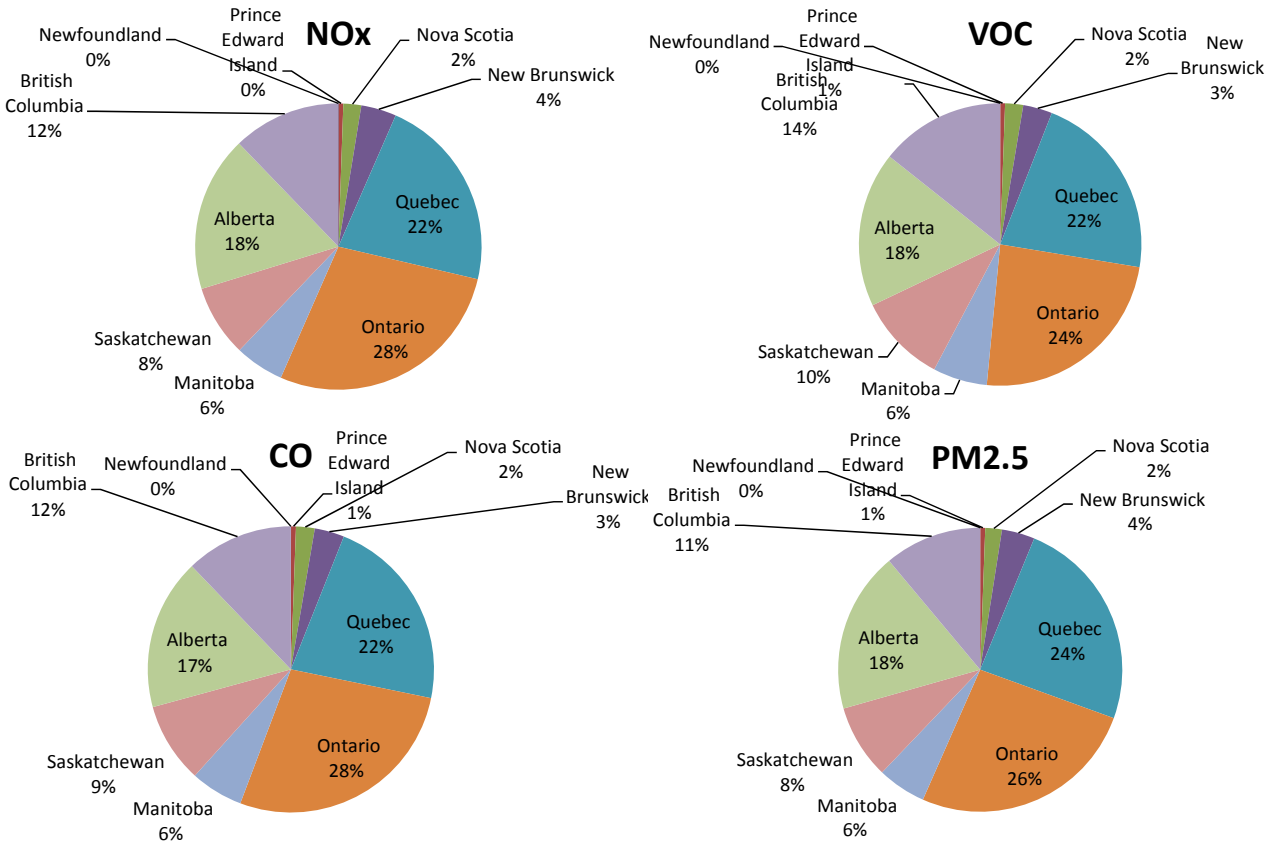

Figure 3. Relative contributions of NO_X, VOC, SO_2 and $PM_{2.5}$ EC 2006 emissions by Province to total on-road mobile source emissions within the Canadian portion of the 36 km CONUS domain.

Table 3 and Figure 4 provide the contributions of the EC 2006 on-road mobile source emissions within the Canada portion of the 36 km COUS domain by SCC category, which includes light duty (LD), medium duty (MD) and heavy duty (HD) vehicles (V) or trucks (T) operating using gasoline (G) or diesel (D) as well as motorcycles (MCY). Heavy Duty Diesel Trucks (HDDV) generate approximately half (52%) of the Canada on-road mobile NO_X emissions with Light Duty Gasoline Vehicles (LDGV) next most important (20%) and the two size categories of light duty gasoline trucks contributing 13% and 9%. On-road mobile gasoline vehicles contribute 95% of the VOC emissions with diesel combustion accounting for only ~5%. LDGV (45%), LDGT1 (26%) and LDGT2 (20%) are the largest contributor to the Canadian on-road mobile source VOC emissions.

Table 3. Summary of EC 2006 Canadian on-road mobile source emissions (tons per day) in the 36 km CONUS domain by Source Classification Code (SCC).

SCC	Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
2201001000	LDGV	5,524	284	335	32	2	8	4	4
2201020000	LDGT1	3,436	188	190	17	1	4	2	2
2201040000	LDGT2	2,513	123	147	7	1	3	1	1
2201070000	HDGV	358	72	24	1	0	1	1	0
2201080000	MCY	55	4	10	0	0	0	0	0
2230001000	LDDV	5	4	1	0	0	1	0	0
2230060000	LDDT	11	14	6	0	1	2	1	0
2230070000	HDDV	164	749	28	2	10	22	19	3
	Total	12,065	1,438	742	58	15	40	28	12

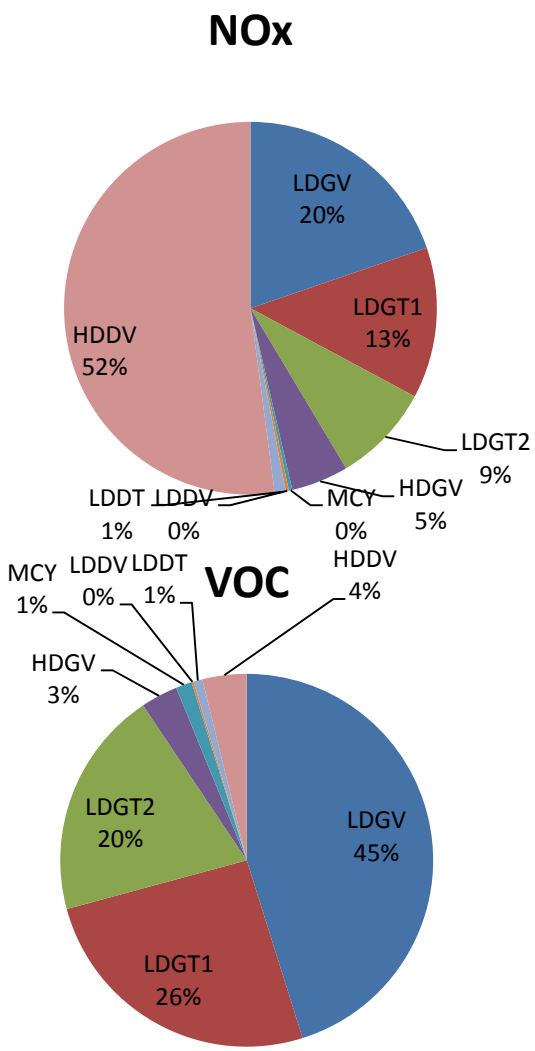

Figure 4. Relative contribution to total on-road mobile source emissions in the Canadian portion of the 36 km CONUS domain by Source Classification Code (SCC).

Canada Area Source Emissions

The EC 2006 area source emissions category includes all sources that are not explicitly treated as point sources or classified as on-road mobile sources. Thus, there are numerous categories in the area source category including non-road mobile source engines (e.g., recreational vehicles, lawn and garden equipment, construction, agricultural, trains, planes and boats), mining, waste disposal, home heating, consumer solvents, area source oil and gas emissions, fugitive dust, and industrial, commercial and residential area source emissions.

Table 4 and Figure 5 display the contributions of area source emissions to the total Canada area sources emissions in the 36 km CONUS domain by Province. As seen for the on-road mobile sources, with one exception, the contribution of area source emissions by Province roughly vary by population with Ontario having the most and Quebec the next most areas source emissions. Again Alberta tends to have more area source emissions than British Columbia even though British Columbia has a slightly higher population, which is likely due in part to more industrial activity (e.g., oil and gas) in Alberta. The exception is for ammonia (NH_3) whose emissions are dominated by livestock and agricultural fertilizer application where Alberta (25%) and Saskatchewan (21%) are the largest contributors.

Table 4. Summary of EC 2006 Canada area source emissions (tons per day) in the 36 km CONUS domain by Province.

Region Number	Province	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
110000	Newfoundland	18	2	6	0	0	1	0	1
111000	Prince Edward Is.	73	7	16	6	3	15	5	10
112000	Nova Scotia	220	26	64	16	14	57	23	34
113000	New Brunswick	293	41	102	12	25	92	34	58
124000	Quebec	2,766	287	816	235	53	649	260	388
135000	Ontario	3,567	611	1,062	293	67	955	279	677
146000	Manitoba	429	120	206	183	8	280	54	226
147000	Saskatchewan	479	221	290	316	31	624	91	533
148000	Alberta	1,185	454	589	369	28	1,628	305	1,323
159000	British Columbia	1,366	240	362	66	32	262	133	130
	Total	10,396	2,009	3,513	1,496	260	4,562	1,184	3,379

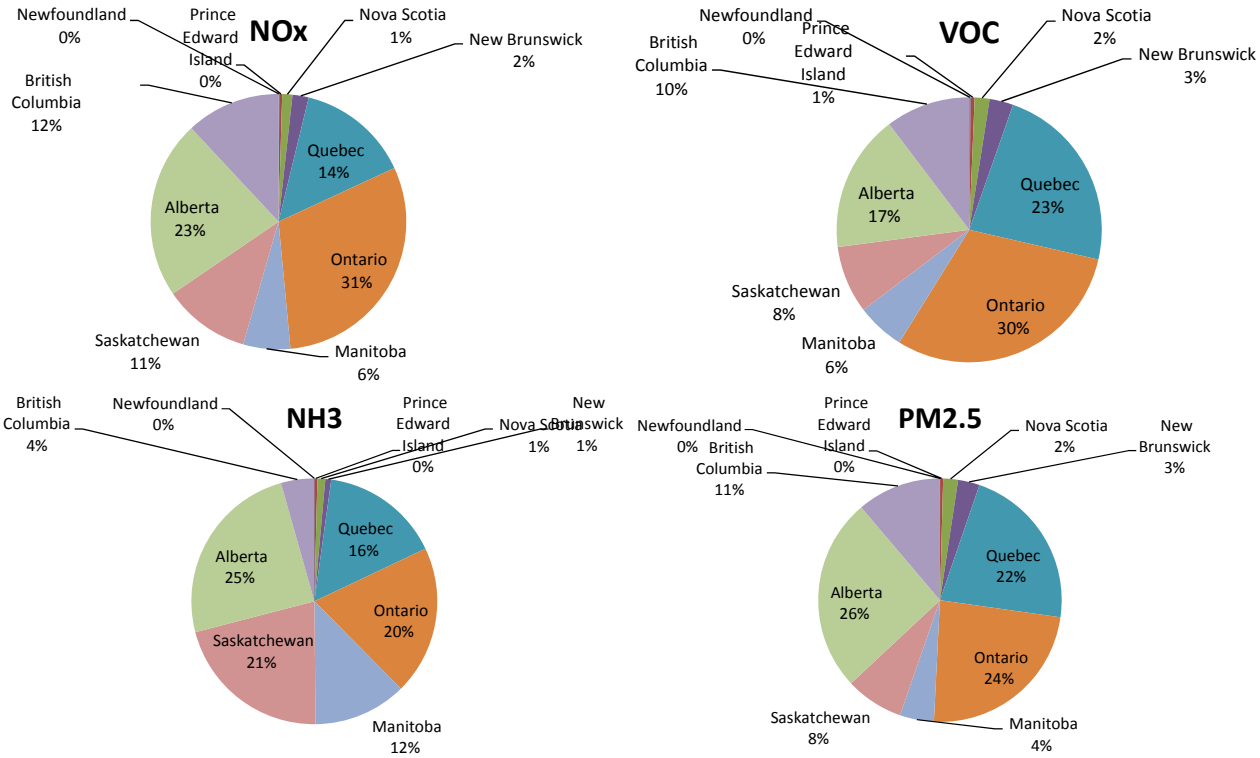

Figure 5. Relative contributions of NO_X, VOC, SO_2 and $PM_{2.5}$ EC 2006 area source emissions by Province to total area source emissions within the Canadian portion of the 36 km CONUS domain.

The EC 2006 area source emissions inventory is classified using 256 SCCs. These SCCs were collapsed into 7 major source categories as given in Table 5. Note that the non-road mobile category includes all non-road engines so is a large category with many different types of sources. Fuel combustion category also includes stationary source fuel combustion from many sources using gas, liquid and solid fuels. The area source NO_X emissions is dominated by the non-road (83%) category, with stationary source fuel combustion being next most important (13%) and other categories being much smaller. The largest contributions to area source VOC emissions include solvents (29%), non-road (25%), agricultural (25%) and fuel combustion (13%). Note that the agriculture category does not include agricultural gas and diesel equipment that is in the non-road category, so actual VOC emissions associated with all area source agriculture activities would be much higher. The agricultural 25% (861 tpd) VOC emissions is almost all from a SCC that is described as "Livestock; Beef cattle production composite; Not Elsewhere Classified" that is not well defined. CO emissions are almost all from non-road (75%) and fuel combustion (20%). Ammonia emissions are all from the agricultural category and are split roughly one third fertilizer applications and two thirds livestock. Half of the SO_2 emissions come from fuel combustion with a little over a third from non-road mobile sources. The three source categories that contribute the most to area source $PM_{2.5}$ emissions are non-road (43%), fuel combustion (27%) and industrial sources (23%).

Table 5a. Summary of EC 2006 Canada area source emissions (tons per day) in the 36 km CONUS domain by major source category.

Source Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
Miscellaneous	7	58	1	2	11	24	24	0
Fuel Combustion	2,101	259	443	6	131	322	320	3
Non-Road Mobile	7,792	1,674	867	2	92	2,396	513	1,883
Industrial	467	17	93	4	13	974	272	702
Solvent	0	0	1,025	0	0	0	0	0
Waste Disposal	30	2	224	0	14	10	8	2
Agricultural (w/o Non-Road)	0	0	861	1,482	0	835	47	788
Total	10,397	2,009	3,514	1,496	260	4,563	1,184	3,379

Table 5b. Summary of percent contribution of EC 2006 Canada area source emissions in the 36 km CONUS domain by major source category.

Source Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
Miscellaneous	0.1%	2.9%	0.0%	0.1%	4.1%	0.5%	2.1%	0.0%
Fuel Combustion	20.2%	12.9%	12.6%	0.4%	50.4%	7.1%	27.0%	0.1%
Non-Road Mobile	74.9%	83.3%	24.7%	0.1%	35.2%	52.5%	43.3%	55.7%
Industrial	4.5%	0.8%	2.6%	0.2%	5.0%	21.4%	23.0%	20.8%
Solvent	0.0%	0.0%	29.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Waste Disposal	0.3%	0.1%	6.4%	0.0%	5.4%	0.2%	0.7%	0.1%
Agricultural (w/o Non-Road)	0.0%	0.0%	24.5%	99.1%	0.0%	18.3%	4.0%	23.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Canada Spatial Emission Maps

Figure 6 displays the spatial distribution of emissions for the Canada point, on-road mobile and area/non-road source categories and the NO, PAR and SO_2 species. NO is typically the largest (~90%) component of NO_X emissions and PAR (Paraffin) is the largest of the VOC species in the CB05/CB6 photochemical mechanism. The urban corridor from Toronto to Montreal is clearly evident in the emission plots. The industrial, oil and gas and urban development in Alberta is also evident. The point source PAR emissions are due in part to oil and gas development that includes the oil sands areas in northeastern Alberta as well as in the Bakken Formation just over the U.S. border at the Montana/North Dakota state line. The off-shore marine shipping is evident out of the Port of Vancouver in the area/non-road source sector plots.

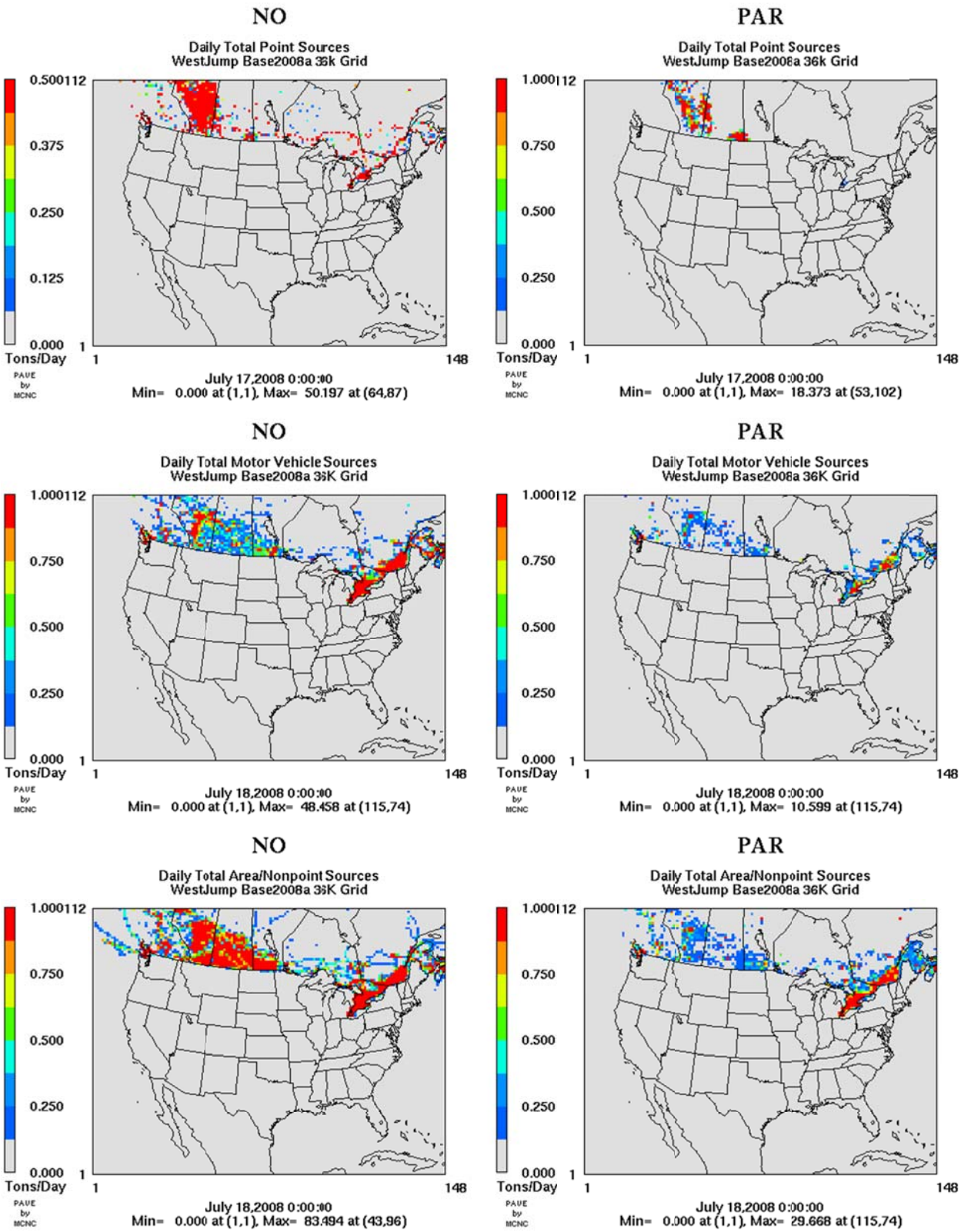

Figure 6a. Spatial distribution of Canada EC 2006 NO (left, representing NO_X) and PAR (right, representing VOC emissions (tons per day) for point source (top), on-road mobile source (middle) and area/non-road source (bottom).

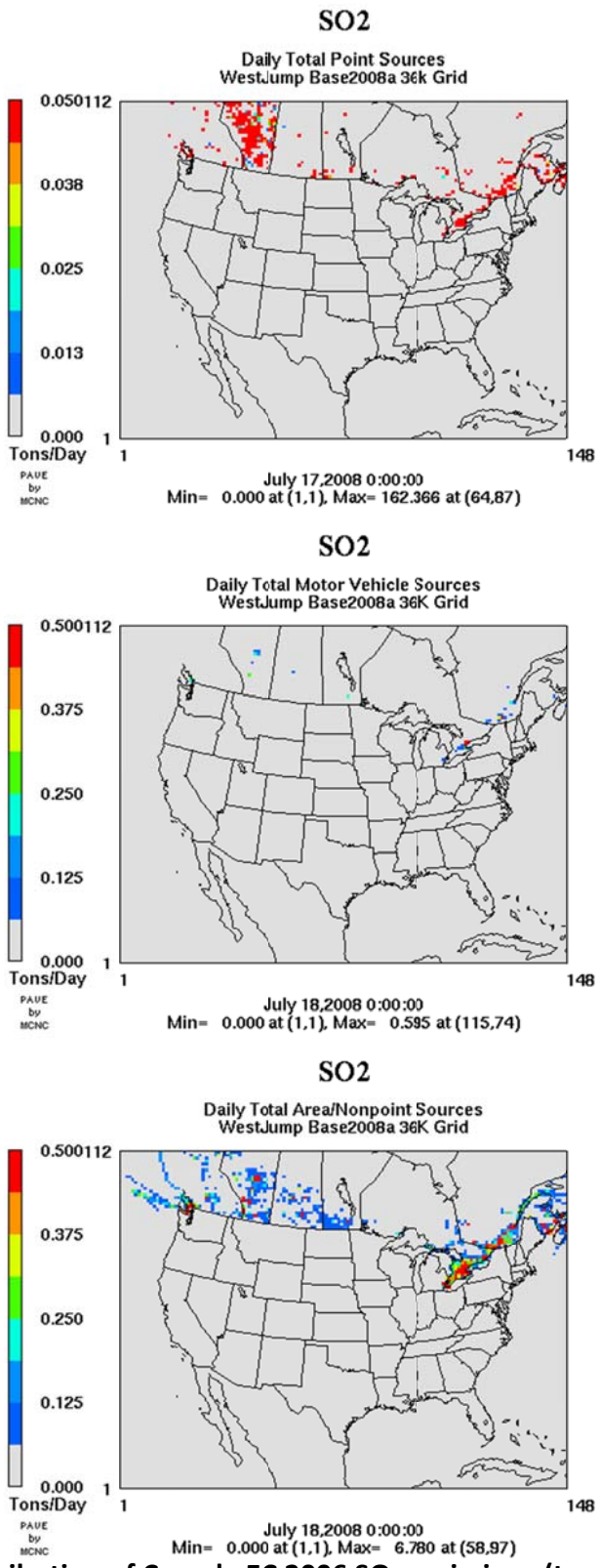

Figure 6b. Spatial distribution of Canada EC 2006 SO_2 emissions (tons per day) for point source (top), on-road mobile source (middle) and area/non-road source (bottom).

Summary of Canada Emissions

Table 6 and Figure 7 summarize the EC 2006 emissions in the Canada portion of the 36 km CONUS domain by major source category. Point sources contribute the most NO_X (40%) followed by area sources (35%), which also includes the non-road source sector, with on-road mobile sources contributing 25%. Area sources contribute the most VOC (64%) followed by area/non-road (22%) and on-road mobile (14%). SO_2 is dominated (94%) by point sources, whereas NH_3 is dominated by area sources (93%). Fine particulate is mostly area source (85%) with little point sources (13%), whereas PM_{10} and PMC are even more dominated by the area source category. CO is produced primarily by gasoline and to a lesser extent diesel combustion so is mostly in the on-road mobile (47%) and area/non-road (40%) source categories.

Table 6. Summary of contribution of point source, on-road mobile sources and area/non-road source contributions to EC 2006 Canada area source emissions in the 36 km CONUS domain by major source category.

Source Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
Point	3,481	2,350	1,226	58	4,559	321	188	134
Mobile	12,065	1,438	742	58	15	40	28	12
Area	10,396	2,009	3,513	1,496	260	4,562	1,184	3,379
Total	25,942	5,797	5,481	1,612	4,834	4,923	1,401	3,525
Percent Contribution								
Point	13.4%	40.5%	22.4%	3.6%	94.3%	6.5%	13.4%	3.8%
Mobile	46.5%	24.8%	13.5%	3.6%	0.3%	0.8%	2.0%	0.3%
Area	40.1%	34.7%	64.1%	92.8%	5.4%	92.7%	84.5%	95.9%

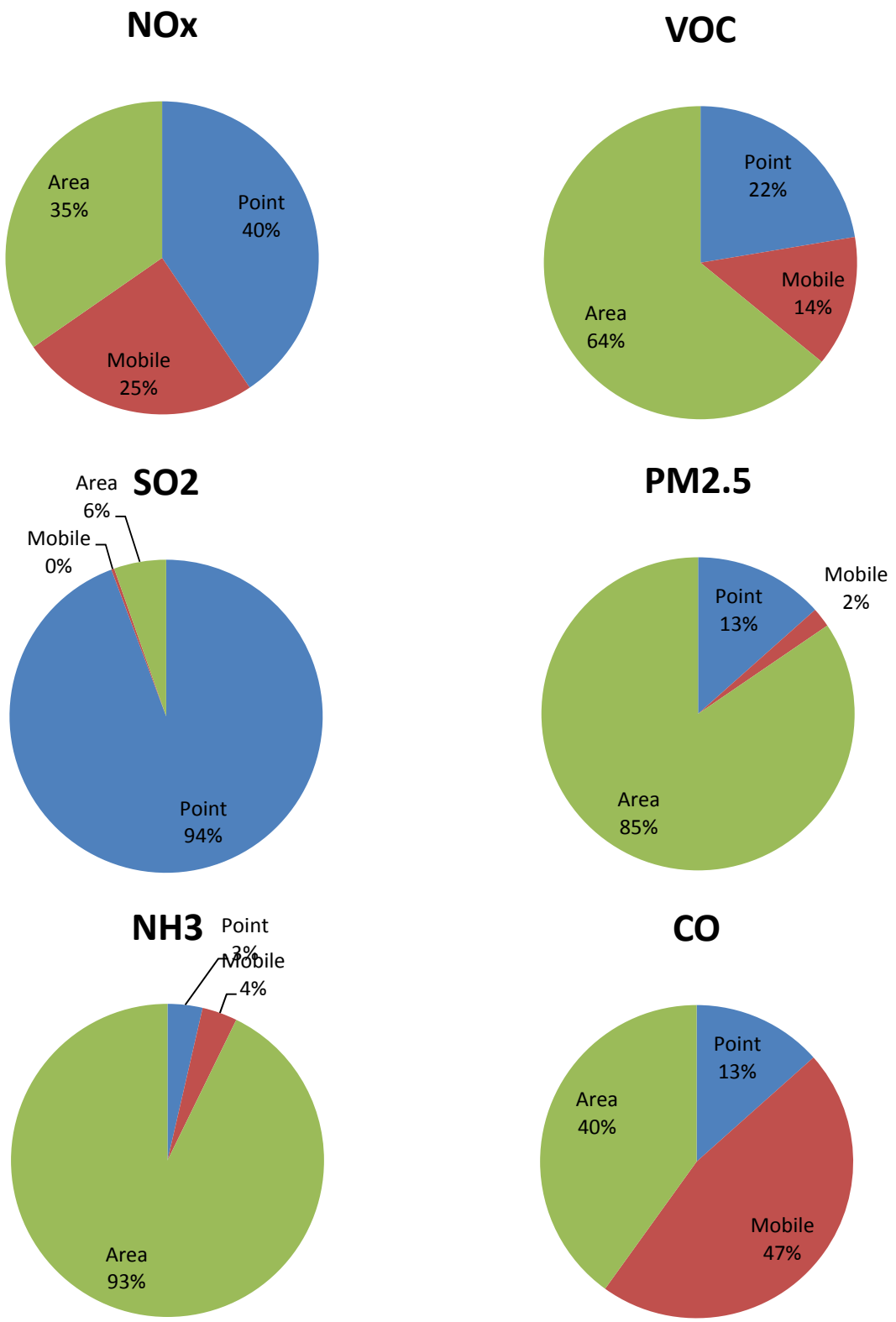

Figure 7. Contribution of point, on-road mobile and area/non-road sources to total emissions in the Canada portion of the 36 km CONUS domain.

MEXICO EMISSIONS

The WestJumpAQMS is using year 2008 projections off of the 1999 Mexican National Emission Inventory (MNEI) to represent anthropogenic emissions sources for Mexico. The 1999 MNEI was finalized in the year 2006 and represented a joint effort between U.S. and Mexican government agencies.[3] The MNEI includes annual estimates of NO_X, SO_X, VOC, PM_{10}, $PM_{2.5}$, and NH_3 emissions for the entire country of Mexico at the municipality level from point, non-point/area, on-road mobile, off-road mobile and natural sources. As the first national-scale inventory for Mexico, the 1999 MNEI was designed to meet the following objectives[3]:

- Comply with the Mexican Federal Environmental Law mandate to integrate and update a National Emissions Inventory for Mexico;
- Promote Mexican institutional capacity-building to compile, maintain, and update emissions inventories;
- Provide a technical basis for improved air quality and health impact analyses in Mexico and the U.S.;
- Assist with regional haze requirements in the U.S.; and
- Support the development of a tri-national emissions inventory of criteria pollutants for Mexico, the U.S. and Canada.

The year 1999 was selected as the inventory year because of data accessibility within Mexican government agencies and to correspond with the U.S. EPA triennial national emissions inventory (NEI) cycle. While the 1999 MNEI represented a significant improvement over previous emissions estimates for Mexico, there were several opportunities to improve the quality of the data and to increase the quantity of data used to estimate the emissions.

In the year 2009, the Western Governors' Association sponsored Eastern Research Group, Inc. (ERG) to project the 1999 MNEI to 2008, 2012, and 2030.[4] This work was used to support research at the National Institute of Ecology in Mexico and the National Renewable Energy Laboratory in the U.S. Continuing with the same spatial coverage (national, municipality-level) and pollutants in the 1999 MNEI, ERG derived growth and control factors from various sources of historical economic indicators and emissions trends and from forecasts of energy use, technology changes, and economic changes.

In the summary of the projections trends for the 1999 MNEI, ERG states the following:

"In general, the emissions from point sources, area sources, and non-road mobile sources are projected to increase in future years relative to the 1999 base year. The projection factors for these source types are primarily driven by population growth, growth in gross domestic product

3 http://www.epa.gov/ttn/chief/net/mexico/1999_mexico_nei_final_report.pdf
4 http://www.wrapair.org/forums/ef/inventories/MNEI/2018_Mexico/2009-01_Mexico_Projections_2008-2012-2030_Final_Report_01-09.pdf

(GDP), and fuel growth. There are also a few source categories with decreasing emissions (i.e., area source SO_2, PM_{10}, and $PM_{2.5}$); these are due to projected decreases in certain fuel types and uses (e.g., commercial combustion of residual fuel oil and residential wood combustion). On-road motor vehicle NO_X, SO_2, VOC, and CO emissions are projected to decrease in future years relative to the 1999 base year, while PM_{10}, $PM_{2.5}$, and NH_3 emissions increase. Although the demand for motor vehicle fuel will increase in the future, the decreases in NO_X, SO_2, VOC, and CO emissions are due to effects of new control technologies that are gradually incorporated into the overall vehicle fleet due to turnover, as well as low sulfur fuels. Because new motor vehicle standards are not being implemented for PM_{10}, $PM_{2.5}$, and NH_3, emissions are projected to increase in the future for these pollutants."[4]

The 2008 MNEI was prepared for air quality modeling with the SMOKE emissions processor for area/non-point and off-road mobile sources, stationary point sources, and on-road mobile sources. Biogenic emissions for Mexico were prepared using the MEGAN biogenic model (see WestJumpAQMS Technical Memorandum #9). Emissions from the active volcanoes in Mexico were not included in the WestJumpAQMS inventory because year 2008 data were not readily available for these sources. Temporal allocation of the MNEI annual inventories to month, day-of-week and hour-of-day used U.S. EPA profiles and assignments based on inventory Source Classification Codes (SCC). Spatial distribution of the municipality non-point and mobile sources to the 36/12/4 km modeling domains was also based on SCCs using spatial surrogate distributions provided by the Mexican National Institute of Ecology. Chemical speciation for the MNEI was also based on speciation profiles and SCC assignments from the U.S. EPA.

The following section presents Mexico state totals by general inventory sector in the 2008 MNEI. These summaries reflect the magnitudes and locations of the emissions that are used in the 2008 WestJumpAQMS.

Mexico Emissions Results

Mexico Point Sources

Table 7 shows the Mexico point source emissions by state. There are no ammonia emissions in the Mexico point source inventory. There are 131 separate SCCs in the Mexico point source inventory. All of the MNEI point sources are identified by SCCs that only define 3 tiers of the SCC structure; the fourth tier of the SCC is the most specific descriptor of a facility and often describes the dominant emissions-producing process at the facility. Stripping the last tier from the SCC structure was done intentionally to de-identify specific processes at the Mexican facilities. The result of this confidentiality measure on the emissions processing is that these sources may not get the proper temporal and/or chemical speciation profile assignments.

Table 7. Summary of Mexico point source emissions (tons per day) in the 36 km CONUS domain by State.

Region Number	State	CO (tpd)	NO_X (tpd)	VOC (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
201000	Aguascalientes	0	1	9	6	2	1	1
202000	Baja Calif Norte	4	31	68	42	15	11	3
203000	Baja Calif Sur	7	36	4	27	4	3	0
205000	Coahuila	74	545	21	704	105	102	4
208000	Chihuahua	67	119	12	295	32	28	4
210000	Durango	5	27	63	47	6	5	1
214000	Jalisco	0	0	0	0	0	0	0
218000	Nayarit	5	2	4	5	8	3	6
219000	Nuevo Leon	100	136	90	548	56	51	5
223000	Quintana Roo	1	11	3	3	1	1	0
224000	San Luis Potosi	12	23	9	152	29	17	12
225000	Sinaloa	6	17	6	165	18	10	8
226000	Sonora	11	32	6	296	105	39	65
228000	Tamaulipas	45	44	107	330	23	14	8
230000	Veracruz	12	5	5	32	17	8	9
231000	Yucatan	0	0	4	0	0	0	0
232000	Zacatecas	0	2	0	0	2	1	1
	Total	348	1,030	411	2,653	423	294	129

Mexico Mobile Source Emissions

Tables 8 and 9 summarize the Mexico on-road mobile source emissions by state and SCC, respectively, with Figure 8 displaying the relative contribution of the Mexico mobile source inventory for NO_X and VOC. The state of Nuevo Leon has the most emissions of all the Mexican states in the 36 km CONUS domain. Nuevo Leon includes the city of Monterey, which is the third largest city in Mexico. The two largest cities, Mexico City and Guadalajara, are outside of the southern boundary of the 36 km CONUS domain. HDDV contributes the most on-road mobile NO_X emissions (58%), followed by LDGV (23%) and LDGT (15%). On-road mobile VOC emissions are dominated by gasoline vehicles, with LDGV and LDGT contributing 58% and 32%, respectively.

Table 8. Summary of Mexico on-road mobile source emissions (tons per day) in the 36 km CONUS domain by State.

Region Number	State	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
201000	Aguascalientes	89	11	12	0	1	1	1	0
202000	Baja Calif Norte	236	34	35	1	2	3	3	0
203000	Baja Calif Sur	23	3	3	0	0	0	0	0
205000	Coahuila	201	26	27	1	1	2	2	0
208000	Chihuahua	280	37	38	1	2	3	3	0
210000	Durango	115	14	15	0	1	1	1	0
211000	Guanajuato	14	2	2	0	0	0	0	0
213000	Hidalgo	0	0	0	0	0	0	0	0
214000	Jalisco	16	2	2	0	0	0	0	0
218000	Nayarit	47	7	7	0	1	1	1	0
219000	Nuevo Leon	631	95	97	3	6	8	7	1
222000	Queretaro	1	0	0	0	0	0	0	0
223000	Quintana Roo	37	5	6	0	0	0	0	0
224000	San Luis Potosi	163	19	21	1	2	2	2	0
225000	Sinaloa	159	23	23	1	2	2	2	0
226000	Sonora	141	20	21	1	1	2	2	0
228000	Tamaulipas	218	31	32	1	2	3	3	0
230000	Veracruz	14	2	2	0	0	0	0	0
231000	Yucatan	25	3	4	0	0	0	0	0
232000	Zacatecas	72	8	9	0	1	1	1	0
	Total	2,485	344	355	11	23	29	27	2

Table 9. Summary of Mexico on-road mobile source emissions (tons per day) in the 36 km CONUS domain by SCC.

SCC	Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
2201001000	LDGV	1,376	80	207	5	9	9	8	1
2201060000	LDGT1&2	898	52	114	4	8	8	7	1
2201070000	HDGV	124	12	16	0	1	0	0	0
2201080000	MCY	14	1	2	0	0	0	0	0
2230001000	LDDV	1	0	0	0	0	0	0	0
2230060000	LDDT	0	0	0	0	0	0	0	0
2230070000	HDDV	72	198	15	1	3	12	12	1
	Total	2,485	344	355	11	23	29	27	2

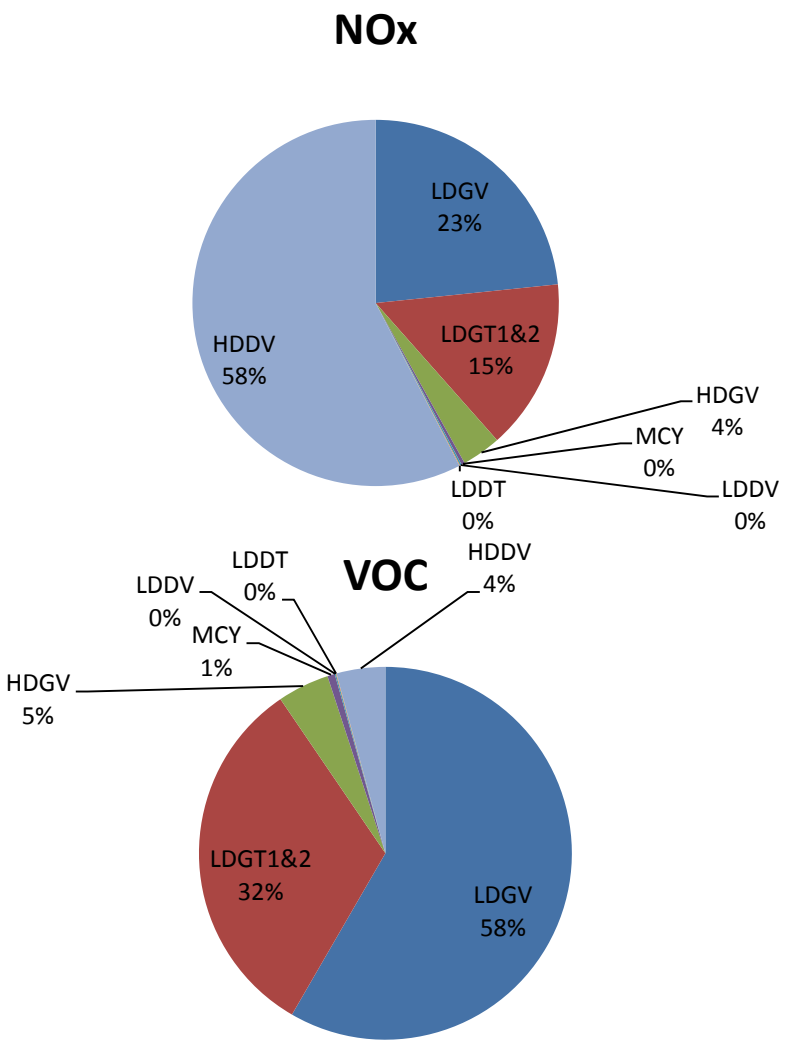

Figure 8. Relative contributions of different vehicle types to total on-road mobile source emissions in the Mexico portion of the 36 km CONUS domain.

Mexico Area Source Emissions

Tables 10 and 11 summarize the Mexico area source emissions by state and SCC, respectively. The non-road source category contributes the most NO_X emissions to the area source category (83%), with stationary source fuel combustion contributing most of the rest these emissions (13%). Over half of the area source VOC emissions come from the solvent category (52%) with miscellaneous (12%), fuel combustion (9%), petroleum transfer and storage (7%) and non-road (7%) contributing the rest. Ammonia emissions are dominated (88%) by the agricultural category and are almost all due to livestock and fertilizer application (split 70%/30%). Fuel combustion dominates (95%) the SO_2 emissions. $PM_{2.5}$ comes from several source categories, including agriculture (40%), combustion (24%), miscellaneous (17%) and non-road (13%).

Table 10. Summary of Mexico area source emissions (tons per day) in the 36 km CONUS domain by State.

Region Number	State	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
201000	Aguascalientes	39	19	80	19	11	9	5	5
202000	Baja Calif Norte	163	77	209	28	39	20	15	5
203000	Baja Calif Sur	20	26	25	9	3	3	3	1
205000	Coahuila	126	62	181	42	18	17	12	5
208000	Chihuahua	279	114	273	87	59	56	35	21
210000	Durango	192	40	113	76	3	42	26	15
211000	Guanajuato	27	4	14	7	1	6	4	2
213000	Hidalgo	0	0	0	0	0	0	0	0
214000	Jalisco	35	9	20	37	1	9	5	4
218000	Nayarit	88	20	46	28	2	16	12	4
219000	Nuevo Leon	142	67	271	46	31	22	17	5
222000	Queretaro	5	0	2	1	0	1	1	0
223000	Quintana Roo	55	9	27	3	1	7	6	1
224000	San Luis Potosi	330	48	155	77	1	55	42	13
225000	Sinaloa	206	69	136	76	1	51	30	21
226000	Sonora	251	75	162	78	1	37	27	10
228000	Tamaulipas	188	99	195	56	1	44	25	19
230000	Veracruz	65	5	23	12	0	10	8	2
231000	Yucatan	70	11	29	19	0	10	9	1
232000	Zacatecas	134	49	84	79	7	47	22	25
	Total	2,415	802	2,045	783	182	461	301	160

Table 11a. Summary of Mexico area source emissions (tons per day) in the 36 km CONUS domain by major source category.

Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
Combustion	774	104	175	0	173	112	105	7
Non-Road	893	680	127	0	8	62	60	2
Industrial	15	0	13	0	0	22	9	13
Solvent	0	0	998	0	0	0	0	0
Petroleum	0	0	140	0	0	0	0	0
Agricultural	234	0	22	688	0	189	58	131
Miscellaneous	498	16	448	95	1	77	70	8
Total	2,415	802	1,921	783	182	461	301	160

Table 11b. Percent contribution of Mexico area source emissions (tons per day) in the 36 km CONUS domain by major source category.

Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
Combustion	32.1%	13.0%	9.1%	0.0%	95.1%	24.2%	34.7%	4.4%
Non-Road	37.0%	84.9%	6.6%	0.0%	4.5%	13.4%	19.8%	1.3%
Industrial	0.6%	0.0%	0.7%	0.0%	0.0%	4.7%	3.0%	7.9%
Solvent	0.0%	0.0%	52.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Petroleum	0.0%	0.0%	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Agricultural	9.7%	0.0%	1.1%	87.9%	0.0%	40.9%	19.4%	81.5%
Miscellaneous	20.6%	2.0%	23.3%	12.1%	0.4%	16.7%	23.1%	4.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Mexico Spatial Emission Maps

Figure 9 displays the spatial distribution of emissions for the Mexico point, on-road mobile and area/non-road source categories and the NO and PAR species. The major cities in northern Mexico are clearly evident, such as Monterey and Tijuana, Mexicali and Juarez on the border with the U.S. The buildup on the western coast of Mexico is also seen.

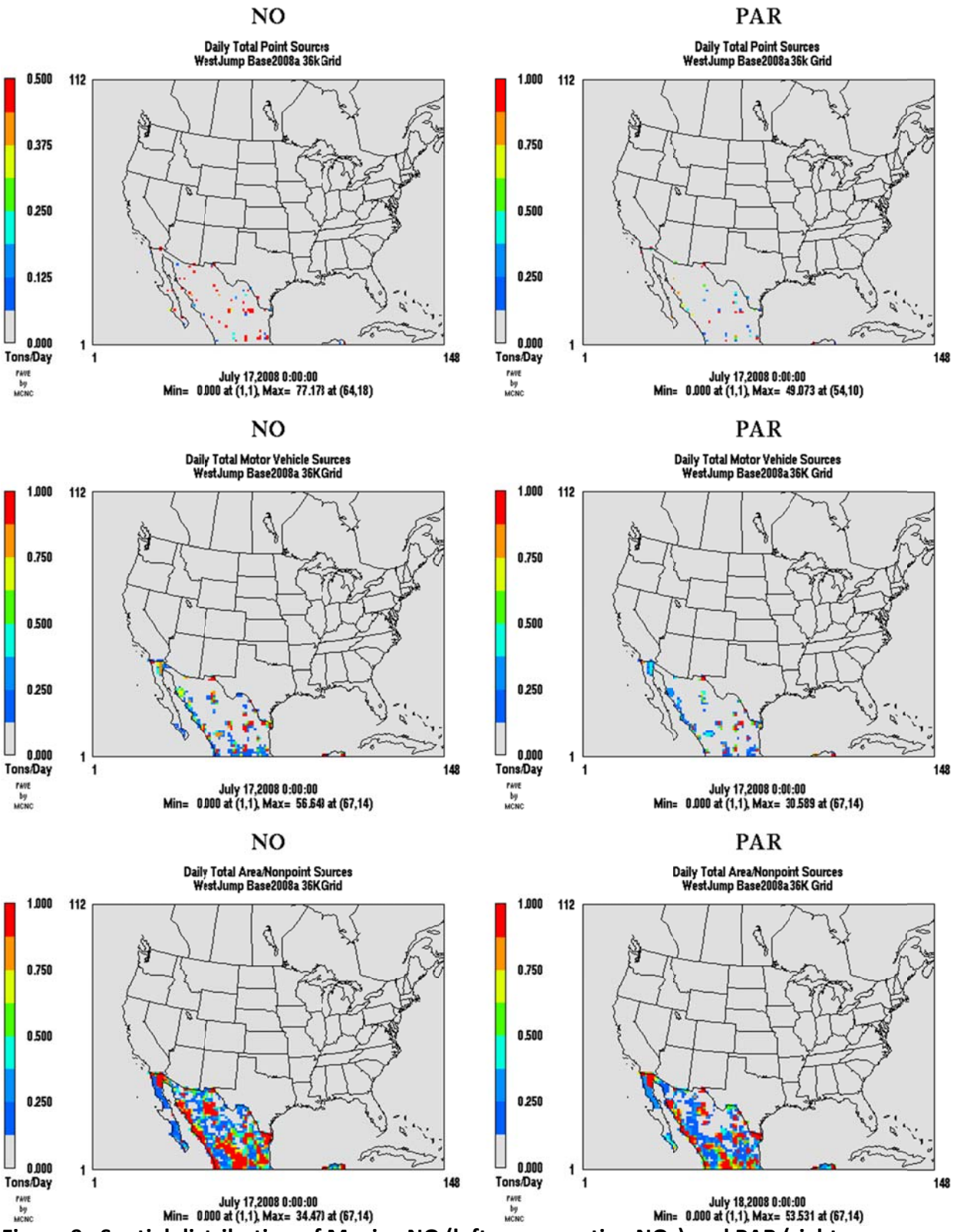

Figure 9. Spatial distribution of Mexico NO (left, representing NO_X) and PAR (right, representing VOC) emissions (tons per day) for point source (top), on-road mobile source (middle) and area/non-road source (bottom).

Summary of Mexico Emissions

Table 12 and Figure 10 summarize the Mexico emissions in the Mexico portion of the 36 km CONUS domain by major source category. As seen in other country's emissions inventories: NO_X emissions are split among the three major source categories; a majority of the VOC emissions come from area sources; a majority of the SO_2 emissions come from point sources; $PM_{2.5}$ is split almost equally between area and point sources; ammonia is almost all from area sources (livestock and fertilizer) and CO is primarily from gasoline combustion from the on-road and non-road (area) mobile source categories.

Table 12. Summary of contribution of point source, on-road mobile sources and area/non-road source contributions to Mexico emissions in the 36 km CONUS domain by major source category.

Source Category	CO (tpd)	NO_X (tpd)	VOC (tpd)	NH_3 (tpd)	SO_2 (tpd)	PM_{10} (tpd)	$PM_{2.5}$ (tpd)	PMC (tpd)
Point	348	1,030	411	0	2,653	423	294	129
Mobile	2,485	344	355	11	23	29	27	2
Area	2,415	802	2,045	783	182	461	301	160
Total	5,248	2,176	2,810	794	2,858	914	623	291
Percent Contribution								
Point	6.6%	47.4%	14.6%	0.0%	92.8%	46.3%	47.2%	44.2%
Mobile	47.3%	15.8%	12.6%	1.4%	0.8%	3.2%	4.4%	0.7%
Area	46.0%	36.8%	72.8%	98.6%	6.4%	50.5%	48.4%	55.0%

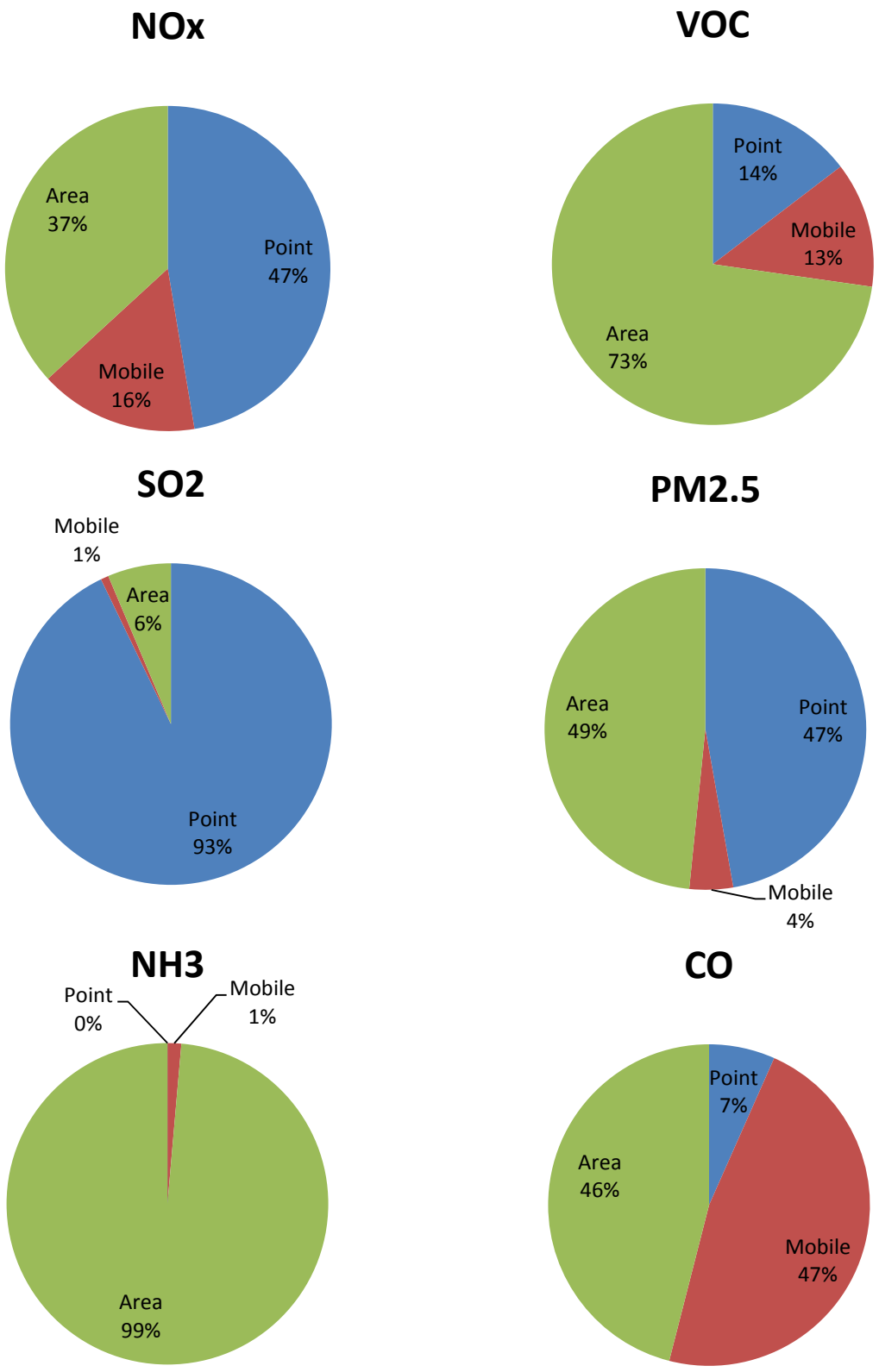

Figure 10. Contribution of point, on-road mobile and area/non-road sources to total emissions in the Mexico portion of the 36 km CONUS domain.

Quality Assurance

Quality assurance (QA) will be performed following the emissions quality assurance protocol developed for the WRAP Regional Modeling Center (Adelman, 2004[5]). These procedures include systematic procedures for:

- Modeling QA – accuracy assurance and problem identification.
- System QA – software and data tracking.
- Documentation – tracking QA issues, recording the QA process and report writing.

An emissions QA checklist is developed that delineates each step of the QA process and allows a systematic approach to the QA process to assure critical steps are not overlooked. The completed QA checklists and templates include:

- Model configuration settings.
- Inventory file log.
- Ancillary input file log.
- Model execution log.

A series of QA products are produced that are compared to other studies and the expected outcomes:

- Spatial plots of emissions by source category.
- Annual time series plots of emissions for subregions.
- Diurnal time series plots.
- Daily vertical profile plots.

5 http://www.epa.gov/ttnchie1/conference/ei13/qaqc/adelman_pres.pdf