Environment Canada Environnement Canada

Uncertainty Analysis of Criteria Air Contaminants from Mobile Sources in Canada

Canada

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Summary

This summary presents the key highlights of a report entitled *Uncertainty Analysis of Criteria Air Contaminants from Mobile Sources in Canada*, prepared by Environment Canada in 2008. The full report is available in PDF format upon request.

Section 1: Introduction

The report presents a statistical analysis of the variables, data, models and methods used for the estimation of emissions of criteria air contaminants (CACs) from mobile sources in Canada. These pollutants affect human health and contribute to air pollution problems such as smog, acid rain and visibility.

Uncertainty analyses are common in the study of greenhouse gas, but they are less common in the study of uncertainties of CAC emission estimates. The report is the first systematic uncertainty study of CAC emission estimates from mobile sources in Canada. The report is designed to be useful for the development and implementation of regulations for air quality management in Canada, for the improvement of inventory accuracy, for decisions on methodological choice, and for all users of the data to understand its strengths and limitations.

The study used Monte Carlo uncertainty analysis to estimate uncertainties related to emissions from various mobile sources. Confidence levels were quantified for emission estimates from aircraft, commercial marine vessels, on-road vehicles, off-road engines and locomotives for six CACs using activity data and emission factors from Canadian, American and European environmental and statistical agencies. The six CACs examined were: particulate matter less than or equal to 10 microns (PM_{10}), particulate matter less than or equal to 2.5 microns ($PM_{2.5}$), sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOC) and carbon monoxide (CO). Insufficient information on methodologies to estimate emissions of ammonia (NH_3) did not allow this pollutant to be considered in the uncertainty analysis.

A summary of Monte Carlo empirical results for each sub-sector is presented in Section 7, Table A.

Section 2: Aircraft

This sub-sector covers CAC emissions from aircraft, but not airport support equipment, such as baggage handling and de-icing vehicles, which are captured under off-road engines. Typically, only landing and take-off cycle (LTO) emissions are inventoried as contributing to ground-level ozone formation. It was difficult to quantify the uncertainty of emission estimates for cruises (taking place above 3 000 feet); however, best estimations were provided.

Section 3: Commercial marine vessels

This sub-sector covers CAC emissions from commercial marine vessels, but not land-based port support equipment, which is captured under the off-road category. This sub-sector is an aggregation of a number of classes of vessels that encompass freighters, tankers, tugs, ferries, passenger boats, fishing boats and container ships.

Section 4: On-road vehicles

This sub-sector covers CAC emissions from vehicles licensed for use on road (paved and unpaved) to transport people and/or goods. The report introduces a probabilistic framework to derive vehicle populations and vehicle kilometres traveled (VKT) for each province.

Section 5: Off-road engines and machines

This sub-sector covers CAC emissions from engines, vehicles and machines not licensed for use on-road. Off-road applications include small spark-ignition engines such as lawnmowers and chainsaws; large spark-ignition engines such as those in forklifts; recreational vehicles and engines such as outboard engines, personal watercraft, snowmobiles and off-highway motorcycles; and off-road diesel engines such as those used in agricultural and construction equipment. While these off-road machines may have various sources of power, only internal combustion engines were considered to determine emission estimates.

Section 6: Locomotives

This sub-sector covers CAC emissions from locomotives, but not rail support equipment (captured under off-road applications). In the past, emission factors and activity levels were entirely estimated or generated by the Railway Association of Canada, but input parameters were varied for the report.

Section 7: Conclusion

Details on activity data, emissions factors, calculations and methodologies used to determine uncertainty levels for each sub-sector can be found in the full report.

Empirical results from the study are summarized in Table A below. This table presents the uncertainty level by pollutant and mobile emission source that was determined by using the Monte Carlo method of uncertainty of analysis. A letter scale, based on a modified version of Statistics Canada's quality indicator, was used to report on uncertainties (see Table B).

Table A – Summary of Uncertainty by Pollutant and Mobile Emission Source (with emission estimates in metric tonnes)

	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO
Total - aircraft	**995[F]**	**995[F]**	**4 841[F]**	**61 442[F]**	**8 218[F]**	**46 357[F]**
LTO	112[B]	112[B]	1 215[F]	6 123[B]	4 060[E]	9 931[C]
Cruise	883[F]	883[F]	3 626[F]	55 319[F]	4 158[F]	36 426[F]
Marine transportation	**5 820[F]**	**5 565[F]**	**32 359[F]**	**117 096[F]**	**8 035[F]**	**9 572[F]**
Total - on-road vehicles	**6 286[B]**	**5 726[B]**	**9 700[B]**	**408 341[B]**	**370 331[C]**	**8 068 222[B]**
Light-duty gasoline vehicles	402[B]	369[B]	740[B]	90 347[D]	153 043[E]	3 502 235[D]
Light-duty gasoline trucks	553[E]	460[D]	943[B]	131 233[B]	205 727[C]	4 502 841[C]
Light-duty diesel vehicles	375[E]	344[E]	419[F]	3 431[F]	1 193[F]	5 791[F]
Light-duty diesel trucks	387[F]	355[F]	598[F]	3 448[F]	1 629[F]	4 281[F]
Heavy-duty gasoline vehicles	54[E]	44[E]	19[E]	4 620[E]	1 310[E]	17 417[E]
Heavy-duty diesel vehicles	4 515[B]	4 154[B]	6 991[C]	175 263[B]	7 430[B]	35 656[B]
Total - off-road engines	**48 254[F]**	**45 248[F]**	**7 434[F]**	**355 299[E]**	**872 464[F]**	**9 429 408[F]**
Off-road use of diesel	16 805[E]	16 301[E]	7 138[F]	230 271[C]	17 959[E]	100 982[E]
Off-road use of gasoline	31 449[F]	28 947[F]	296[F]	125 028[F]	854 505[F]	9 328 426[F]
Total - locomotives	**4 411[A]**	**4 277[A]**	**7 199[F]**	**112 082[A]**	**10 620[A]**	**25 923[A]**
Freight	4 097[A]	3 973[A]	6 624[F]	101 703[A]	9 672[B]	23 705[A]
Switching	139[A]	135[A]	245[F]	4 803[A]	453[A]	971[A]
Passenger	175[A]	170[A]	330[F]	5 576[A]	495[A]	1 248[A]

Table B: Modified Version of Statistics Canada's Letter Scale Quality Indicator

Quality	Coefficient of variation
A - excellent	less than 5%
B - very good	5% to 9.9%
C - good	10% to 14.9%
D - acceptable	15% to 19.9%
E - use with caution	20% to 34.9%
F - high uncertainty	35% or more

The analysis found that uncertainty in the emission estimates varied significantly by source or vehicle type. For example:

- Emission estimates for most CACs from locomotives were found to be “excellent” (coefficient of variation less than 5%), due to the high quality, detail and accessibility of information on the locomotive fleet in Canada. However, emissions of sulphur dioxide from locomotives were found to have a higher level of overall uncertainty, due to the uncertainty related to the differences in fuel characteristics and the spatial distribution of SO_2 emissions.
- Emission estimates for on-road vehicles were found to be “good” to “very good”--similarly due to the quality, detail and availability of statistical information for on-road vehicles in Canada.
- Aircraft, marine transportation and off-road emission estimates were found to have a high level of uncertainty associated with them (coefficient of variation of over 35%) due to the use of highly aggregated data as input for aviation, the sparse data available for commercial marine and the fragmented nature of the spatial distribution of off-road equipment.

The analysis also found that estimation methodologies are closely aligned between various countries, allowing for meaningful country-by-country comparisons, and that off-road engines accounted for more emissions of most pollutants than all on-road vehicles in Canada.

Opportunities for future improvements to mobile source emission estimates include the use of Canadian-specific data that is spatially and temporally distributed at a high level of resolution, the acquisition of the Mobile Source Observation database from the US EPA, the development of improved NO_x correction factors, and additional research on aircraft particulate matter emissions.

For a copy of the full report, please contact the NPRI.

www.ec.gc.ca

Additional information can be obtained at:

Environment Canada
Inquiry Centre
10 Wellington Street, 23rd Floor
Gatineau QC K1A 0H3
Telephone: 1-800-668-6767 (in Canada only) or 819-997-2800
Fax: 819-994-1412
TTY: 819-994-0736
Email: enviroinfo@ec.gc.ca