

2010 Canadian CACs Emission Inventories for the Air Quality Modelling Platform Supporting Policy Regulations

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Abstract

Environment Canada (EC) developed an updated air quality modelling platform used to assess the impact of current and future Criteria Air Contaminants (CACs) emissions on the environment and the human health. Current platform configuration is based on year 2010, updating from a 2006 platform configuration. Among the various changes to the platform, the one of interest for this presentation is the update of the emission inventories. 2010 Canadian CAC emissions inventory, compiled by the Pollutant Inventories and Reporting Division (PIRD) of EC, was used to prepare air quality modelling inputs. Both top-down and bottom-up approaches were used for the compilation and a link to the complete documentation is available upon request. The 2010 inventory database compiled by PIRD was then further processed by the Air Quality Modelling Applications Section (AQMAS) of EC for the 2010 Canadian air quality modelling platform. As a result a first package was put together and provided upon request to the air quality modelling community in summer 2014. A second version of the package is expected to be ready during summer 2015. In this presentation, an overview of these source-sector-specific updates along with the description of the platform emission inventories will be presented.

Introduction

AQMAS has finalized the migration of its current 2006-based emissions platform to 2010 base year to efficiently support regulatory impacts on health and the environment. This migration has become necessary as many updates have been made available since the 2006 platform was released in late 2010. Part of this migration, 2010 Canadian CACs emissions inventory files were acquired from Canada's Air Pollutant Emission Inventory (APEI) of EC for all anthropogenic sectors. The original files were compiled by PIRD and provided to the AQMAS group in the beginning of 2014. The files include updated estimates of point, area and mobile sources emissions. However, wild fire emissions are based on fire events and locations data provided by the Canadian Wildland Fire Information System (CWFIS) and the EC FireWork system¹.

The focus of this paper is on the updates and features of the 2010 Canadian emissions inventory components. These updates and features are part of version 1 of this inventory (referred here to as 2010-v1) and are presented first. The components of this inventory are detailed next with a special focus on some key sectors such as mobile, point and wild fire sectors. This section will be followed by a description of the details about how to

access the emissions inventory package and the shapefiles for the surrogates. Concluding remarks are drawn finally.

New updates and features in the 2010 Canadian emissions inventory

Compared to the 2006 Canadian emissions inventory, improvements to the 2010-v1 Canadian emissions inventory include change to point, mobile and area sources inventories.

- *Point sources*

Some industrial stack heights were missing from EC 2006 point sources inventory and were included in the 2010 inventory using updated data from National Pollutant Release Inventory (NPRI) division. In addition, a particular effort was made on the temporal allocation aspect in a sense that facility-specific temporal profiles were applied to temporally allocate the emissions rather than applying temporal profiles based on the SCC codes. This feature was developed based on 2010 Canadian NPRI point sources monthly operation schedule using an internal algorithm². From a technical point of view, profile numbers are linked to NPRI IDs facilities. As not all the facilities have operation schedule, sub-class average profiles were calculated and used for the facility in that sub-class without operation schedule.

Another improvement is related to the chemical speciation where other individual Volatile Organic Compounds (VOC) speciation's (CB05, SAPRC07) are now part of the 2010 inventory instead of having only ADOM-II speciation available. These speciation data can be provided on request.

- *Mobile sources*

A first update was that on-road emissions inventory files were generated using a 'Canadianized' version of MOVES for heavy duty gasoline and diesel vehicles while MOBILE6.2C was used for the other categories. A second update consisted of taking out the oil sands fleet emissions from the off-road files and treating them as point sources (emitting at the surface) based on the geographical location of the facilities.

- *Area sources*

There are two major updates in the 2010 area sources inventory. The first one concerns fugitive dust emissions which are processed based on grid point land use Transportable Fraction (TF) approach as recommended by Pace *et al.*³, rather than using a census division dominant land use approach as done for the 2006 platform⁴. In the new methodology, land use at 5-km resolution, originally interpolated from BELD3 (Biogenic Emissions Land use Database, version 3) dataset at 1-km resolution⁵, were used to generate TF at 45-km resolution for continental grid and TF at 15-km resolution for two other regional grids. Note that the grid point land use TF was applied after the fugitive dust inventory was processed with the Sparse Matrix Operator Kernel Emissions (SMOKE). As a consequence, the dust ORL files that are part of the inventory package

(see section entitled “2010-v1 Canadian platform packages” below) do not account for the adjustment by TF. The second update concerns 2010 agriculture ammonia emissions which were spatially allocated over Canadian provinces and territories using 54 detailed surrogates compared to only 4 surrogates for 2006 agriculture ammonia emissions.

How 2010 emissions compare with 2006 emissions?

From a national perspective, the 2010 inventory shows a general decrease in emissions trends compared to 2006 inventory (see Figure 1) for all CAC which agrees with the actions under the Clean Air Regulatory Agenda (CARA). The CARA program is supported by the Canadian government to reduce emissions of many sectors such as transportation, electricity, and other sectors to help achieve Canadian economy-wide 2020 target of a 17 % reduction in greenhouse gas emissions from 2005 levels (Canada’s Economic Action Plan, 2011)⁶. The highest reduction (more than 25%) is for sulfur dioxide (SO₂) emissions from industrial and non-industrial point sources whereas as the lowest reduction (less than 10%) is in VOC. Overall, these reductions seem to be consistent with regards to the regulations in place related to transportation sector, coal-fired electricity sector, and other sources of electricity over the period 2006-2010 (Canada’s Economic Action Plan, 2011).

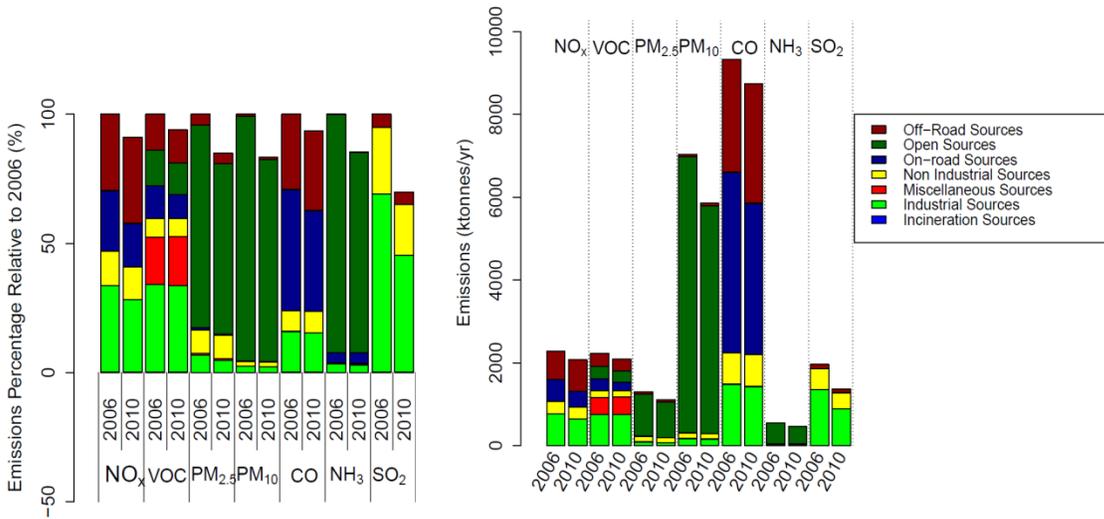


Figure 1: Comparison between 2010 and 2006 Canadian CACs emissions inventories (relative estimates (left) and absolute estimates (right)).

2010 Inventory Components

The 2010 Canadian emissions inventory includes data for eight anthropogenic sector categories with annual or monthly emission files depending on the sector category. Table 1 presents the anthropogenic sectors of the 2010 platform with the forest fire sector and their respective files for the SMOKE processing. In addition to the anthropogenic emissions, 2010 biogenic emissions were also part of the 2010 platform but were

calculated online using the Biogenic Emission Inventory System (BEIS) v3.0 with 2010 meteorological fields and Landuse Database, v 3.0 (BELD3).

Table 1: 2010 Canadian CACs emissions inventory components

Sector Short Name	Sector Description	Inventory Temporal Resolution (and Format)	Treated with SMOKE as
UOG	Upstream oil and gas sector	One annual file (ORL)	Point
NPRI	Point sources	Annual (ORL)	Point
NAESI	Agriculture	Monthly (ORL)	Area
ON-ROAD	On-road vehicles	Monthly files for Heavy Duty Vehicles and for other vehicle categories (ORL)	Mobile
OFF_ROAD	Aircrafts and locomotives, oil sand fleet and other off-road categories.	Two annual files and 12 monthly files (all in ORL)	All mobile except oil sand fleet treated as non-elevated point.
OAREA	Residential wood combustion, solvent use and other areas sectors.	Three annual files (ORL)	Area
DUST	Dust from agriculture, roads & construction	One annual file (ORL)	Area
MARINE	Marine engines C1, C2 & C3	Two annual files (ORL)	Mobile
FIRE	Wild fire	Day-specific files from April to October 2010 (EMS-95 and IDA).	Point

Point sources

The 2010 point sources emissions inventory is composed of two sectors: the NPRI point sources sector (industrial facilities) and the upstream oil and gas (UOG) sources sector (extraction and production facilities). The UOG facilities are below the reporting limit of NPRI and thus were not part of the NPRI point sources inventory. They were provided by a private company and as a consequence they have different format and size compared to NPRI inventory. NPRI facilities are reported at the facility level within two files, one for speciated VOC emissions (CB05 mechanism for the 2010-v1 package) and the other one for non-VOC emissions. They also come with facility-specific and year-specific monthly, weekly, and daily temporal profiles. For the emissions processing with SMOKE, these facility-specific profiles were extracted and added to the setting files.

The UOG facilities are also provided at the facility level similarly to the NPRI inventory, but they do not have stack parameters. The data was compiled within only one file including the UOG emissions but this file does not include oil sand fleet emissions which were treated separately.

Mobile sources

The mobile sector was separated into on-road sources and off-road sources. The 2010 Canadian on-road emissions inventory was provided by PIRD. The emissions were estimated using the United States Environment Protection Agency (EPA) Motor Vehicle Emission Simulator (MOVES, <http://www.epa.gov/otaq/models/moves/>) for HDDV and HDGV only. For the other sectors, version 6.7 of MOBILE6.2C which is an adapted version of EPA MOBILE6.2 model (<http://www.epa.gov/oms/m6.htm>) for the Canadian context was used. Emissions estimates were generated on a provincial level with a monthly temporal resolution. For British Columbia (BC), Ontario (ON) and Quebec (QC), emissions estimates were generated with a significant level of details to properly capture the effects of inspection and maintenance programs in each province. This was done by sub-dividing BC into 8 geographical sub-regions, ON into four geographical sub-regions and QC into 2 geographical sub-regions. Note that meteorological data for each province, territory or region were from the Global Environmental Multiscale (GEM) model and monthly maximum and minimum temperatures were integrated into the model to account for summer and winter fuel properties.

The 2010 Canadian off-road emissions inventory includes off-road engines and equipment which encompass engines, vehicles and machines not licensed for on-road use such as small and large spark-ignition engines, recreational vehicles and off-road diesel engines used in agricultural, construction and mining sectors. In order to compile the inventory for these sources, estimates were calculated for all engines using gasoline, compressed natural gas (CNG), and liquefied petroleum gas (LPG) and diesel fuel. Monthly emission estimates were therefore generated using EPA NONROAD6.7 model (<http://www.epa.gov/oms/nonrdmdl.htm>) on a provincial level. The off-road inventory includes also all types of aircrafts but not airport support equipment. Emissions from aircrafts are in turn composed of landing/take-off (LTO) and cruise (in-flight). Conceptually, a LTO is a complete landing/take-off cycle and includes idle, taxi, climb-out and descent/approach. The cruise component is all flights above 3000 feet. Typically, only emissions from the LTO are inventoried as contributing to ground-level ozone formation. Aircraft emission estimates were generated with a yearly temporal resolution on a provincial level. The off-road sector includes also the marine emissions from all marine vessels, but not land-based port support equipment or recreational marine engines. The marine sector is an aggregation of a number of classes of vessels such as commercial marine, ferries, fishing and harbour vessels. The inventory is generated yearly at the provincial level and covers 200 nautical miles from the Canadian coasts. Another component of the off-road sector is the locomotives sector where the emissions were calculated for diesel engines with a yearly temporal distribution on a provincial level.

Wildfire emissions

Wildfire emissions are day-specific for events occurring from April 2010 to October 2010. The data consists of satellite derived latitude/longitude of the fire's origin and other parameters associated with the emissions such as acres burned and fuel consumed. The point source day-specific emission estimates for 2010 fires rely on version 1 of the Canadian FireWork system. This system is based on CWFIS and involves the use of fire location information as input combined with the Fire Emission Production Simulator (FEPS) emissions module as well as the Fuel Characteristic Classification System (FCCS) fuel-loading database to estimate fire emissions from wildfires and prescribed burns on a daily basis. More details on the FireWork system can be found in ⁶.

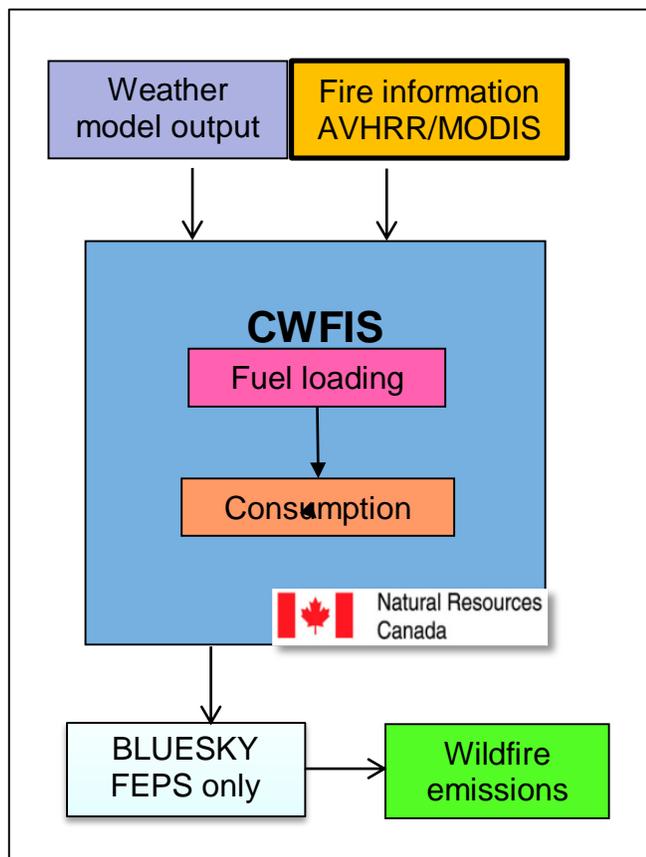


Figure 2: A functional diagram of the FireWork components

2010-v1 Canadian platform packages

Two different packages were created separately: one includes all the 2010 Canadian emissions inventory files and the other includes the shapefiles to generate the surrogates. More specifically, these packages include inventory files for nine sectors (including

wildfire sector), SMOKE ancillary files and scripts to perform emissions processing and Canadian configuration files for the spatial allocator (SA) tool v4.1 of the Community Modelling & Analysis System (CMAS) to generate the surrogates. The inventory package comes also with a documentation that describes the files of each sector. Note that the shapefiles correspond to 2006 base year and that changes in the spatial allocation of emissions are assumed to be minor over the period from 2006 to 2010. The inventory package and the shapefiles package are available on request from reqa@ec.gc.ca until a permanent ftp site is available.

Conclusion

A first version of the 2010 Canadian emission inventory was developed for EC policy air quality modelling platform and is now available upon request. While this version is being used, an updated version will become available during summer 2015 and a package will officially be released as version 2010-v2. As for future developments, the next emissions modelling year should be based on base year 2014 and the first version of the 2014 emission inventory is expected to be available in 2016.

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Key words

Emissions inventories, updates, platform, 2010 base year