Quantification, Spatial Distribution and Speciation of Vehicular Emissions Using Smoke: a Brazilian Metropolitan Region Case

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ABSTRACT

The air quality of a region is the result of complex interactions involving the emission of air pollutants from stationary and mobile sources, local and remote, natural and anthropogenic, which together with the weather and topography of the region determine concentration of pollutants. Thus, it is crucial understand the emission inventory of pollutants aiming effective management of air quality in a region. The present work conducted the **spatial and temporal modeling of the emissions of traffic routes in the Metropolitan Region of Vitoria (RGV)**, through the **SMOKE emissions model**, using data from the 2010 emission inventory, **using the new emission factors and composition of the current vehicle fleet, proposed by the Ministry of Environment of Brazil**, which had sources georeferenced and temporally allocated, emissions chemically speciated and subsequently included in the SMOKE model. The result showed the emission scenarios the main areas of emission of gases and particles, corroborating with that described in tabulated inventory and **demonstrating the viability of the model** as part of a powerful global tool for environmental management, **and future possibility of using the U.S EPA model Motor Vehicle Emission Simulator (MOVES)** due to national data available for model customization for the Brazilian reality, for **more improvement of emission inventory**.

INTRODUCTION

- Metropolitan Region of Vitoria - RGV (Figure 2): diversity of air pollutants from different kind of sources;
- RGV - four important cities with 1.9 million of inhabitants (50% of all entire state with 78 municipalities);
- **Official emission inventory - Local Environmental Agency (IEMA, 2011)** offers a 2010 based year inventory covering PM, PM_{10}, $PM_{2.5}$, SO_2, NO_X, CO and VOC (Figure 1);

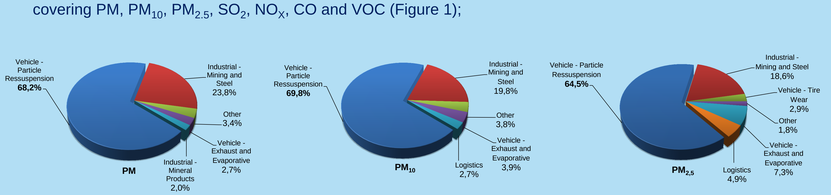
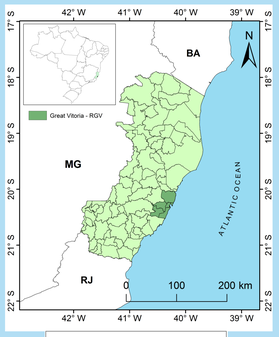


Figure 1. Distribution of particulate matter emissions Rates in RGV – official inventory

- **Last researches at Federal University of Espírito Santo – UFES** (Loriato et al., 2015) have shown that **some inputs used** in the air quality model (**CMAQ**) **are not suitable to represent concentrations when compared to monitoring data**, especially to **particulate matter in all fractions**;



Geographic Coordinates System
Geodetic Reference Sys.: Datum WGS84
Source: IDAF/Owner
Preparation: Rizzieri Pedruzzi
Date: September 2015
Lab.Cart. Geog. e Geotecnologias-UFES

Figure 2. Metropolitan Region of Vitoria

Issues found:

- Simplified use of **just one value** (emission factor) to **represent all ages of vehicles**;
- **Overestimation of ressuspension fraction**, and double counting of emissions from vehicles in the form of exhaust, brake wear, and tire wear due to **use of outdated AP-42 section 13.2.1 Paved Roads (October, 2002)**.

Challenges:

- 706 industrial/commercial/residencial sources, 121 roads;
- **Not all data available to use U.S. EPA's MOVES2010**

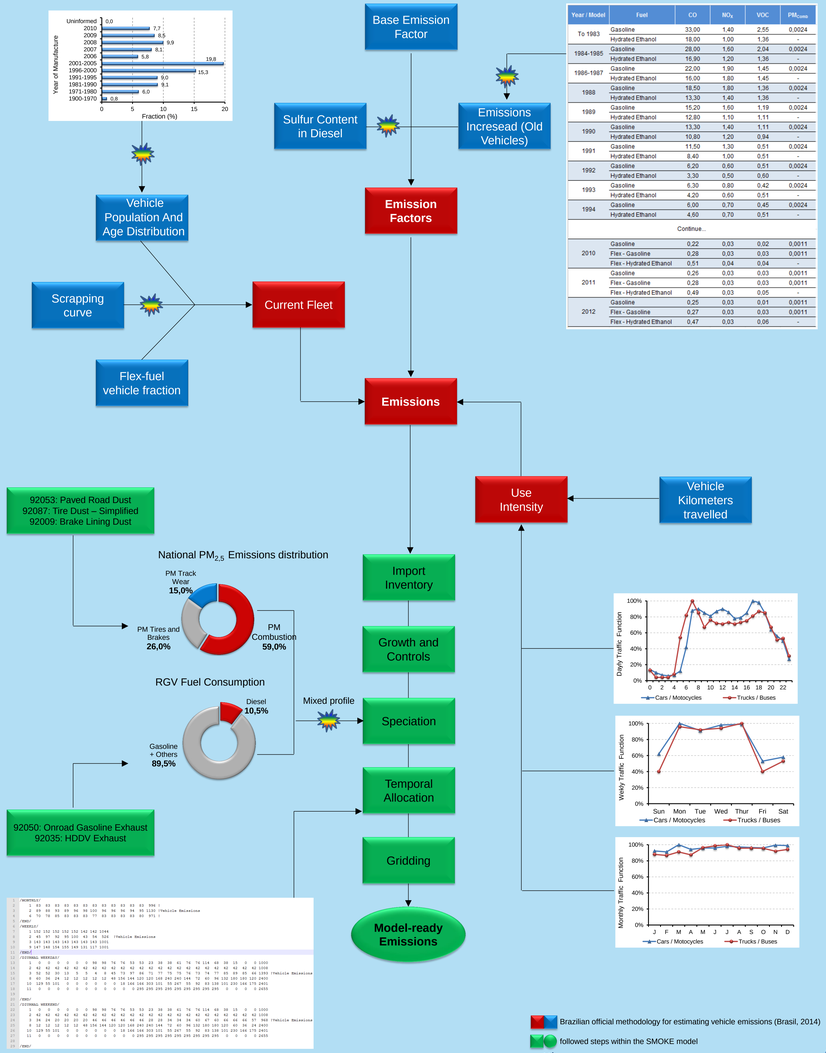
Sollutions:

- **Official Vehicle emissions inventory methodology from Brazilian Ministry of the Environment (Brasil, 2014);**
- Improvements and adaptations with local available data;
- Use of **SMOKE** to georeference, temporally allocate and chemically speciate to air quality modelling.

METHODOLOGY

According Flowchart 1 below, vehicle atmospheric emissions of RGV were recompiled, recalculating emissions rates using **new estimation methodology** (**Brasil, 2014**), identifying the changes obtained in the inventory through its application, linked with the use of **Sparse Matrix Operator Kernel Emissions (SMOKE) v3.5.1** to quantitatively characterize in time and space, and represent their chemical nature (speciation), performing the preparation of the inventory for use in air quality models. SMOKE was used to **prepare spatially and temporally (hourly) averaged vehicular emissions for RGV** and for the year of 2010 again, **comparing the results against existing "official" emission inventory**.

Flowchart 1. Procedures and inputs to create RGV´s vehicular emission inventory



Year / Model	Fuel	CO	NO_X	VOC	PM_{Comb}
To 1983	Gasoline	33,00	1,40	2,55	0,0024
	Hydrated Ethanol	18,00	1,00	1,36	-
1984-1985	Gasoline	28,00	1,50	2,04	0,0024
	Hydrated Ethanol	16,90	1,20	1,36	-
1986-1987	Gasoline	22,00	1,90	1,45	0,0024
	Hydrated Ethanol	16,00	1,80	1,45	-
1988	Gasoline	18,50	1,80	1,36	0,0024
	Hydrated Ethanol	13,30	1,40	1,36	-
1989	Gasoline	15,20	1,60	1,19	0,0024
	Hydrated Ethanol	12,80	1,10	1,11	-
1990	Gasoline	13,30	1,40	1,11	0,0024
	Hydrated Ethanol	10,80	1,20	0,94	-
1991	Gasoline	11,50	1,30	0,51	0,0024
	Hydrated Ethanol	8,40	1,00	0,51	-
1992	Gasoline	6,20	0,50	0,51	0,0024
	Hydrated Ethanol	3,30	0,50	0,60	-
1993	Gasoline	6,30	0,80	0,42	0,0024
	Hydrated Ethanol	4,20	0,60	0,51	-
1994	Gasoline	6,00	0,70	0,45	0,0024
	Hydrated Ethanol	4,60	0,70	0,51	-
Continue...					
2010	Gasoline	0,22	0,03	0,02	0,0011
	Flex - Gasoline	0,28	0,03	0,03	0,0011
	Flex - Hydrated Ethanol	0,51	0,04	0,04	-
2011	Gasoline	0,26	0,03	0,03	0,0011
	Flex - Gasoline	0,28	0,03	0,03	0,0011
	Flex - Hydrated Ethanol	0,49	0,03	0,05	-
2012	Gasoline	0,25	0,03	0,01	0,0011
	Flex - Gasoline	0,27	0,03	0,03	0,0011
	Flex - Hydrated Ethanol	0,47	0,03	0,06	-

RESULTS

- Large discrepancies between this work ("new") and official emission inventory;
- New **SO_2 emission rates are 7 times higher** than official inventory – **sulfur content improvemet**;
- New **NO_X, CO and VOC are (3x), (10x) and (9x) lower** than official inventory – "**aged" emission factors instead average value**;

- PM, PM_{10} and $PM_{2.5}$ are 6 times lower than official inventory to "Exhaust and Evaporative" category. "Tyre Wear" is almost the same (1,07x). **Particle Resuspension have the major discrepancies**:

- All fractions are lower than official inventory: 22x (PM), 82x (PM_{10}) and 157x ($PM_{2.5}$) – new correct U.S EPA formula, **without double counting of "Exhaust and Evaporative", "Brake" and "Tyre Wear" emissions**.

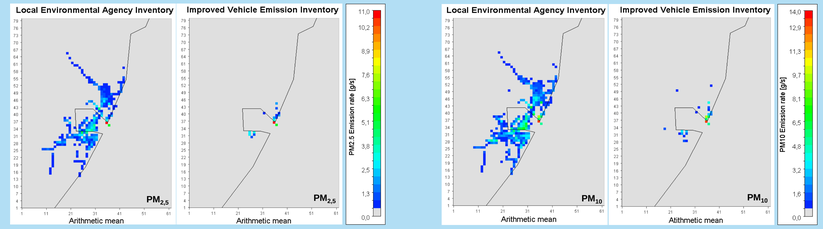


Figure 3. Winter (August/2010) particulate matter emission rate in RGV – inventories compared

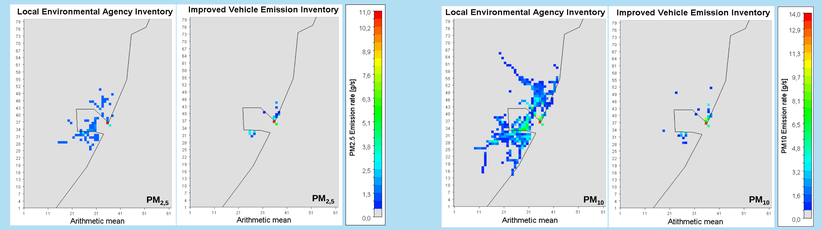


Figure 4. Summer (January/2010) particulate matter emission rate in RGV – inventories compared

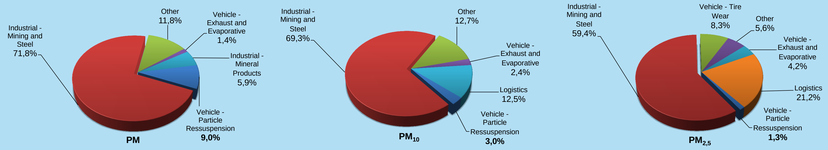


Figure 5. New distribution of particulate matter emissions rates in RGV – improved inventory

CONCLUSIONS

1. RGV official inventory needs to be updated;
2. It presented deficiencies and seems to be overestimated;
3. Brasil (2014) methodology serves as a "tool" to produce local emissions based on national approach.
4. SMOKE proves to be capable in temporal and spatial alocation.

Future Work

1. Test this inventory in CMAQ modeling;
2. Produce more and specific local data;
3. Implement use of U.S. EPA's MOVES2010;
4. Update the inventory to 2014 or 2015.

ACKNOWLEDGMENTS

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