Use of SMOKE model outside of USA: Mobile sources emission inventory using area type approach

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ABSTRACT

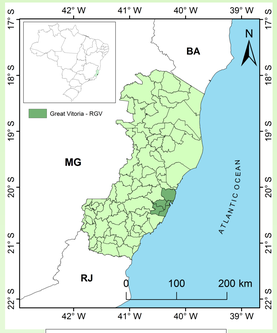
The air quality of a region is the result of complex interactions involving the emission of air pollutants from stationary and mobile sources, local and remote, natural and anthropogenic, which together with the weather and topography of the region determine concentration of pollutants. Thus, it is crucial 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**. In the adaptation of the RGV´s emission inventory, for SMOKE, emission sources of pollutants were divided in two types: point and **area sources**. Area sources were composed of regions exposed to various materials and **urban roads**, commercial and residential emissions. 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 area approach use of SMOKE** 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**

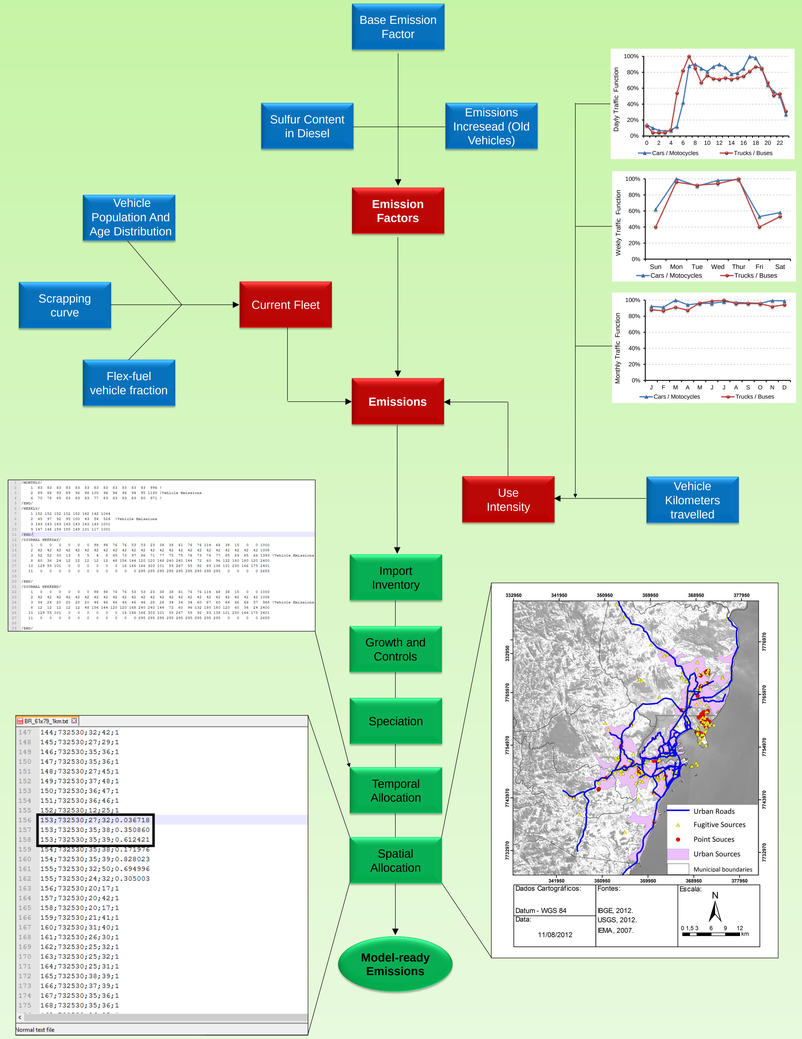
Sollutions:

- **Official Vehicle emissions inventory methodology from Brazilian Ministry of the Environment (Brasil, 2014);**
- Adoption of a **GIS-based road network** as spatial surrogates;
- 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**). Area sources were composed of regions exposed to various materials and **urban roads**, commercial and residential emissions and were divided into two types: sources from vehicular emissions and diffuse sources. **Vehicular sources were treated considering the proportionality between the vehicle flow and road emissions**. The fraction of the area occupied by roads in each cell of the grid was considered an emission source.

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



RESULTS

- Large discrepancies between this work ("new") and official emission inventory;
- New **SO_2 emission rates are 6 times higher** than official inventory – **sulfur content improvemet**;
- New **CO and VOC are (7x) and (5x) 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: 6.7x (PM), 8.3x (PM_{10}) and 8.7x ($PM_{2.5}$) – new correct U.S EPA formula, **without double counting of "Exhaust and Evaporative", "Brake" and "Tyre Wear" emissions**.

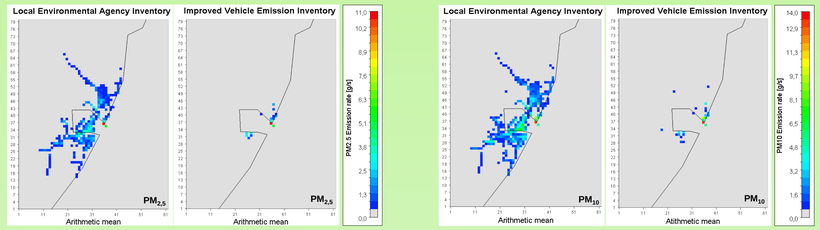


Figure 3. Winter (August/2010) particulate matter emission rate in RGV – inventories compared

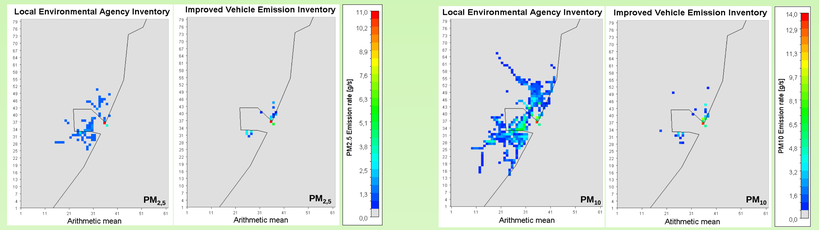


Figure 4. Summer (January/2010) particulate matter emission rate in RGV – inventories compared

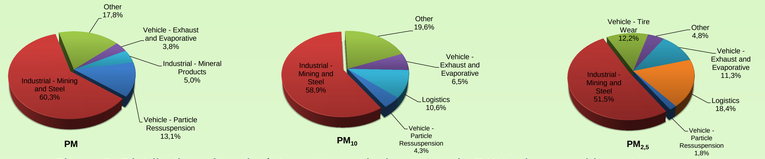


Figure 5. Distribution of particulate matter emissions rates in RGV – improved inventory

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. "Area Sources" approach in SMOKE seems to be capable in temporal and spatial alocation.

Future Work

1. Run this inventory in CMAQ modeling;
2. Produce "silt" content local data;
3. Implement EPA MOVES2014a;
4. Update the inventory "base year".

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REFERENCES (major):

BAEK, B.,H., SEPPANEN, C., AND HOUYOUX, M. SMOKE v.3.5.1 User's Manual. **2013**;

BRASIL. Ministério do Meio Ambiente. Inventário Nacional de Emissões Atmosféricas por Veículos Automotores Rodoviários 2013: Ano-base 2012. **2014**;

IEMA. Instituto Estadual de Meio Ambiente e Recursos Hídricos. Inventário de Emissões Atmosféricas da Região da Grande Vitória, Espírito Santo, **2011**;

LORIATO A. G.; ALBUQUERQUE T. T. A.; SARTORIO R.M.; YNOUE R. Y.; SALVADOR N.; MOREIRA D. M.;1, REIS N. C. INVENTÁRIO DE EMISSÕES COM ALTA RESOLUÇÃO PARA A REGIÃO DA GRANDE VITÓRIA UTILIZANDO O SISTEMA DE MODELAGEM INTEGRADA WRF-SMOKE-CMAQ. **2015**;