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 Vitória (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 allowed the emission scenario to 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 Vitória - RGV (Figure 2): diversity of air pollutants from different kind of sources;
• RGV - four important cities with 1.3 million of inhabitants (50% of all entire state with 78 municipalities);
• Official emission inventory - Local Environmental Agency (EIA, 2011) offers a 2010 based year inventory covering PM, PM, SO, NOx, CO and VOC (Figure 1);

Issues found:
- Simplified use of just one value (emission factor) to represent all ages of vehicles;
- Overestimation of re-suspension 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and double counting of emissions from vehicles in the form of exhaust, brake wear, and tire wear due to use of outdated AP-42 section 13.2.1 Paved Roads (October, 2002).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:
- 76% industrial/commercial/residential sources, 121 roads;
- Not all data available to use U.S. EPA’s MOVES2010

Solutions:
- Official Vehicle emissions inventory methodology from Brazilian Ministry of the Environment (Brazil, 2014);
- Improvements and adaptations with local available data;
- Use of SMOKE to georeference, temporally allocate and chemically specify air quality modeling.

METHODOLOGY
 According Flowchart 1 below, vehicle atmospheric emissions of RGV were recalculated, recalculating emissions rates using new estimation methodology (Brazil, 2014), identifying the changes obtained in the inventory through its application, linked with the use of Sparse Matrix Operator Kernel Emissions (SMOKE) v3.3.1 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 temporarily (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

RESULTS
• Large discrepancies between this work ("new") and official inventory;
• New NO2 emission rates are 7 times higher than official inventory – sulfur content improvement;
• New NOx, CO and VOC are (3x), (10x) and (8x) lower than official inventory – "aged" emission factors instead average value;
• PM1, PM2.5 and PM10 are 6 times lower than official inventory to "Exhaust and Evaporative" category. "Tire Wear" is almost the same (1.07x). Particle Resuspension have the major discrepancies;
• All fractions are lower than official inventory: 22x (PM), 82x (PM2.5) and 157x (PM10) – new correct U.S EPA formula, without double counting of “Exhaust and Evaporative”, “Brake” and “Tire Wear" emissions.

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

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E 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.

Figure 2. Metropolitan Region of Vitória
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

1. Data from the 2010 emission inventory and the SMOKE model were used to simulate the atmospheric emissions of RGV.
2. The results were compared with the official inventory, showing significant discrepancies.
3. The SMOKE model was used to provide a more accurate representation of the chemical nature of the emissions.
4. The work highlights the need for an updated official inventory.

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