UPDATING RESUSPENDED PARTICULATE MATTER (RPM) EMISSIONS OF BOGOTA, BASED ON A RESPONSE ANALYSIS OF SIMULATED PM_{10} CONCENTRATIONS AND THEIR SPECIES USING CMAQ.

Juan Sebastian Montealegre [Δ], James East [†], Johan Sebastian Vanegas [Δ], Jorge E. Pachon [Δ], Fernando Garcia Menendez [†],
[†]North Carolina State University, Raleigh, U.S [Δ] Universidad de La Salle, Centro Lasallista de Investigación y Modelación Ambiental CLIMA, Bogotá, Colombia. Email: clima@lasalle.edu.co

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Introduction

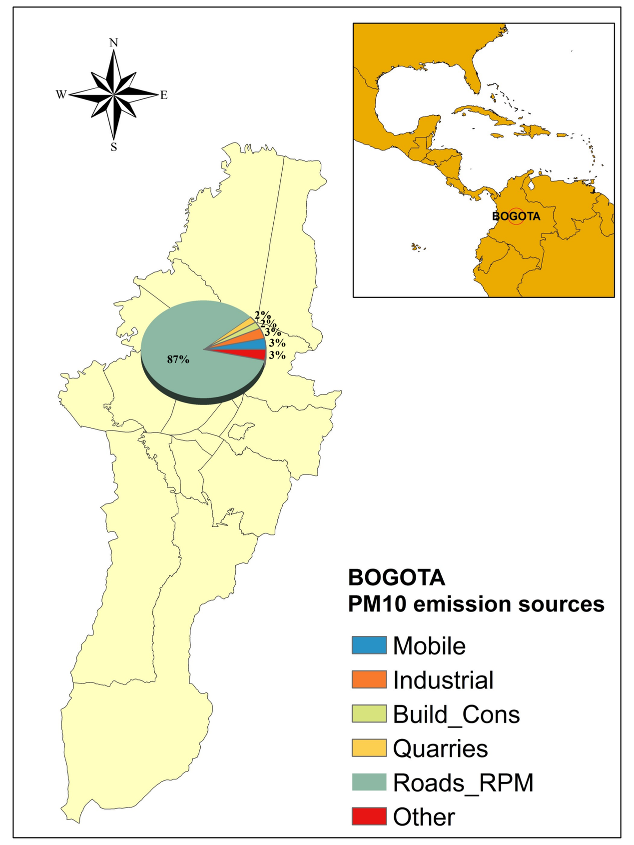
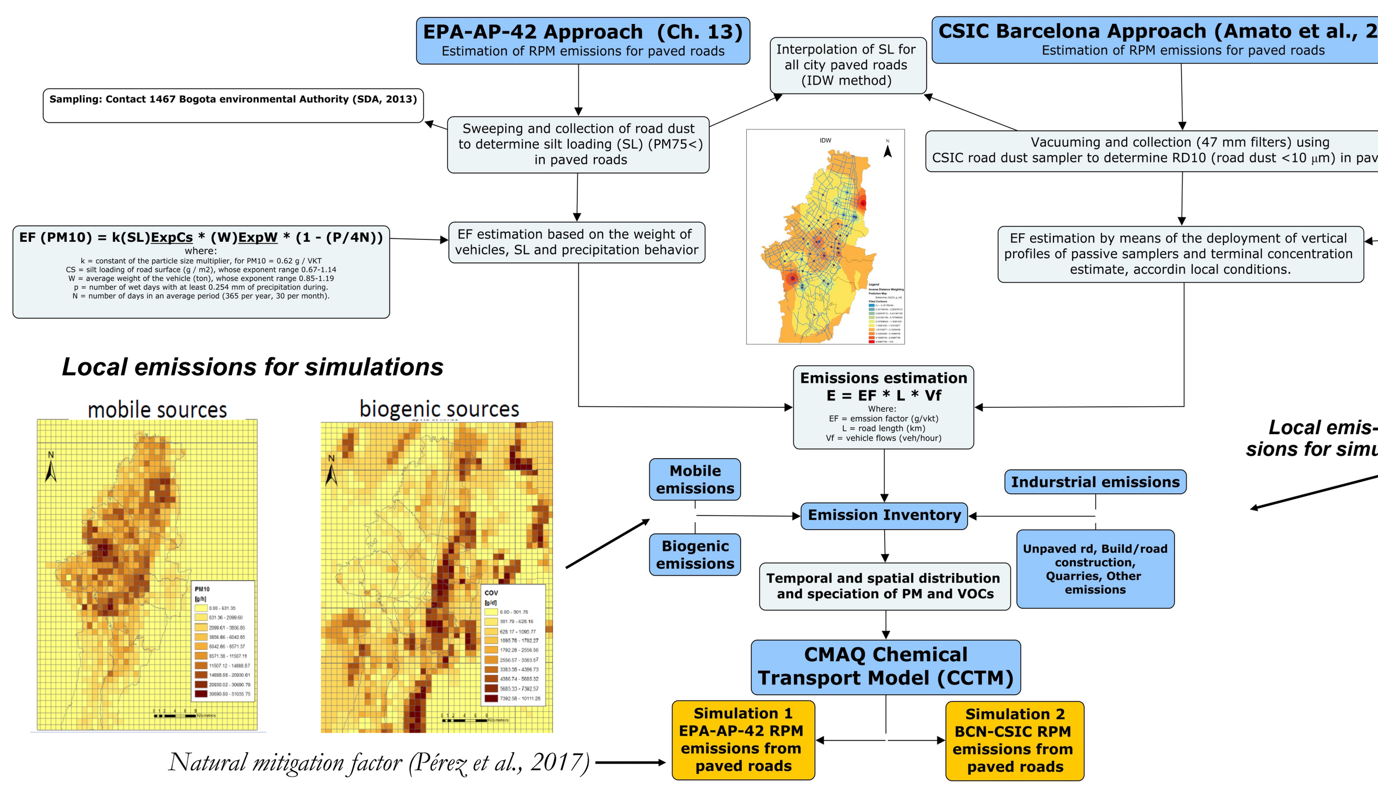


Figure 1. Bogota PM_{10} emissions contribution per source.

- Resuspended particulate matter (RPM) from roads has been identified as the biggest contributor of PM_{10} in Bogota, Colombia.
- A 2014 emissions inventory developed for Bogota showed an 87% contribution to total PM_{10} emissions from roads RPM (ECP & ULS, 2016) (Figure 1).
- Overestimations of modeled PM10 concentrations have been found to be likely caused by RPM road emission calculated using the EPA-AP-42 database (Pachón et al., 2018).
- Some studies have found that the EPA-AP-42 approach is incongruent with actual RPM emission factors (EFs) for paved roads, which have been determined experimentally under local condition.
- Newer approaches consider the influence of dust loading and vehicles weight, as well as other variables such as vehicle speed (Amato et al., 2011).

A pavement program in underway in the city to improve citizens´ quality of life. (Pinto & Mendez, 2017)

Methods



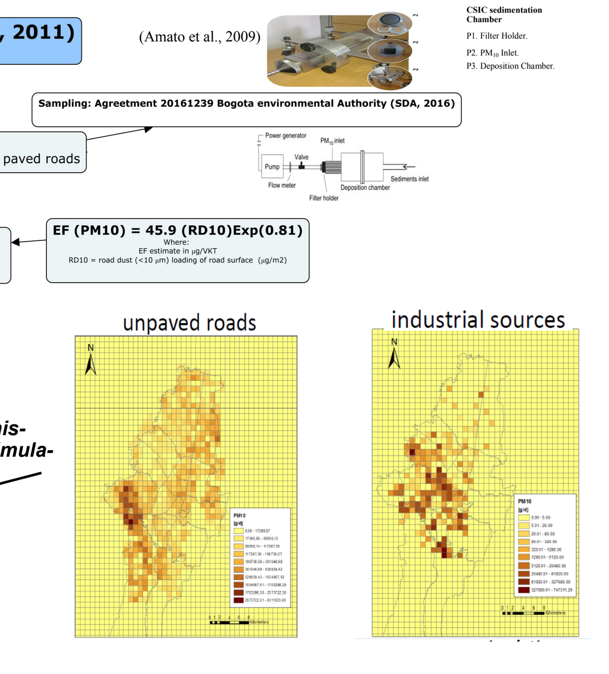
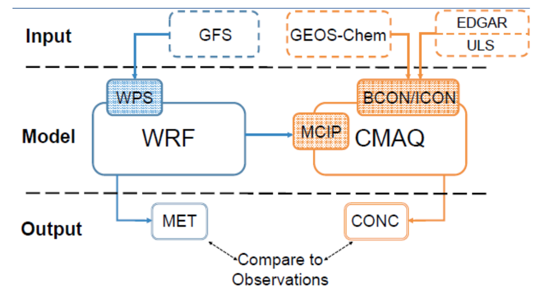
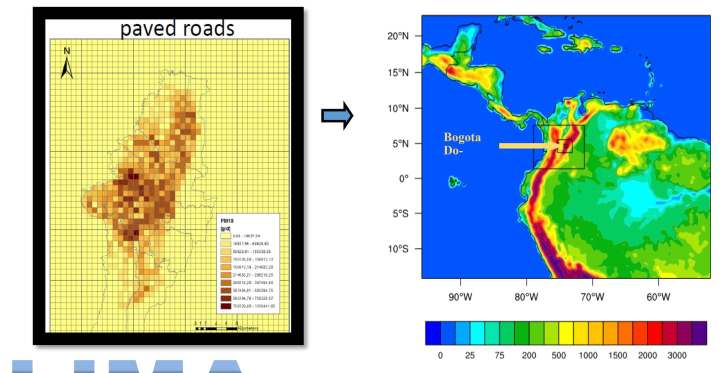


Figure 2. General scheme for CMAQ simulations





- Air quality simulations were performed using CMAQv5.0.2 for the local dry season (January, February, March; JFM), and ocal wet season (October, November, December; OND), base year 2014.
- Simulation domain (64 km x 64 km); resolution (1 km x 1 km); 29 vertical layers.
- ISORROPIA (v2.1) was used for inorganic thermodynamic partitioning aerosols, and AERO6 treatment for organic aerosols.
- Other required inputs including boundary and initial conditions, meteorology, and biogenic emissions match previous studies of Bogota air quality (Nedbor-Gross et al., 2018; Pachón et al., 2018; Pérez et al., 2017) (Figure 2).

Results

1. PM_{10} modeling assessment

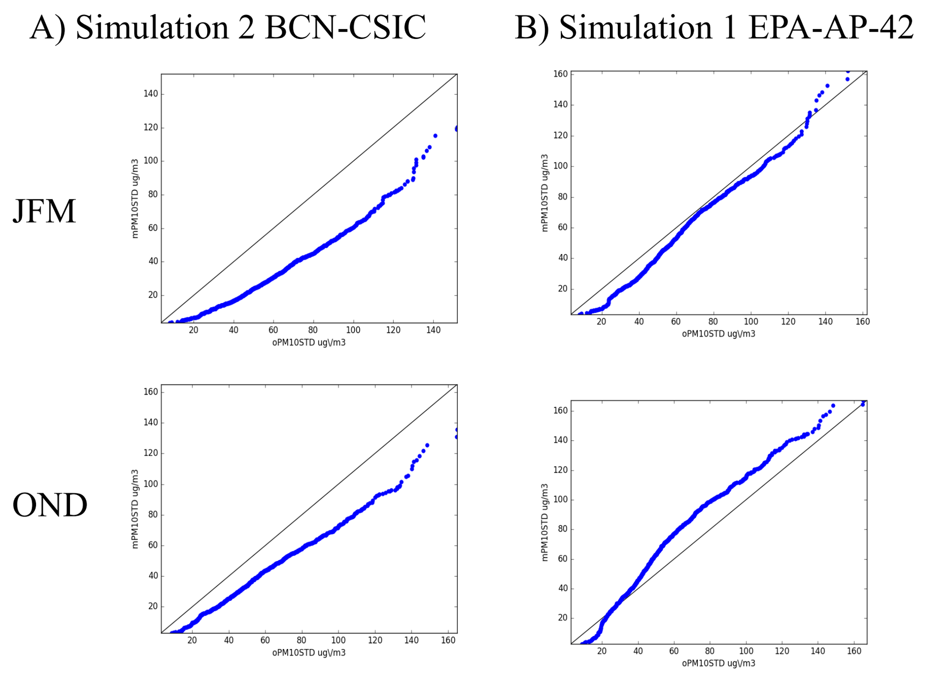


Figure 3. QQ plots for PM_{10}, axis "y" Modeled concentrations, axis "x" Observed concentrations by the RMCAB for both simulations, BCN-CSIC and EPA-AP-42.

QQ plots allow to assess general trends of PM_{10} for the two simulations

Table 1. PM10 annual emission inventory supplied for CMAQ simulations

Simulations	Assessing Bogota anual PM10 emissions	
	All emission sources (Ton/yr)	ONLY paved roads RPM emissions (Ton/yr)
1. EPA-AP-42	45,707	19,534
2. BCN-CSIC	28,269	1,834
Differences	-38%	-91%

Table 1 shows PM_{10} emissions for both simulations. The BCN-CSIC approach for paved roads decreases total emissions by 38%.

- CMAQ predictions for PM_{10} were evaluated for simulated PM10 using recommended model performance metrics (Boylan & Russell, 2006).
- Observed concentrations (2014) reported by Bogota Air Quality Network (RMCAB) were used in the assessment.
- PM_{10} concentrations simulated using RPM emissions (paved roads) estimated under BCN-CSIC approach, showed an underestimation trend (Figure 3).
- In comparison with simulations applying EPA-AP-42 , BCN-CSIC simulation not consider average of first 3 layers to avoid overestimations in the night (00 UTC to 13 UTC).
- Statistical performance for both simulations are presented in Table 2.

Table 2. Model performance statistics for both simulations and seasons based on Boylan & Russell (2006)

Simulation	MFB JFM avg	MFB OND avg	MFB both seasons	MFE JFM avg	MFE OND avg	MFE both seasons
EPA-AP-42	0.06[2]	0.13	0.09	0.42[2]	0.42	0.42
BCN-CSIC	-0.31[1]	-0.23[2]	-0.27	0.52[2]	0.38[2]	0.45

[1]Five stations of eleven, with outlier (discarded)
[2]Two stations of eleven, with outlier (discarded)

Other Concerns

- Temporality of RD10 sampling (SDA & ULS, 2017) could affect emissions, since it was done in a rainy season (Amato et al., 2012) (Figure 3, BCN-CSIC simulation JFM).
- Although OND season showed an underestimation in the concentrations, a good performance was evidenced in simulation 2.

2. Chemical component analysis of PM_{10} modeleded

$$PM_{10} = PMIJ + ATOTK\ (ASOILJ + ACORS + ASEACAT + ACLK + ASO4K + ANO3K + ANH4) \quad \textbf{(1)}$$

Table 3. Species used for the analysis of PM10 composition in CMAQ

PM_{10} (Spec)	CMAQ output variables
SIA	ASO4IJK, ANO3IJK, ANH4IJK
CL	ACLI, ACLJ, ACLJ
EC	AECI, AECJ
OM	AOMIJ
SOIL	ASOILJ
ACORS	ACORS
OTHER	AOTHRI, AOTHRJ, AUNSPEC1IJ

- A chemical component analysis of simulated PM_{10} was performed for the two simulations with different models to estimate RPM emissions.
- CMAQ species definition from "COMBINE" tools was used where PM_{10} is represented by the sum of the masses in the Aitken ("I"), acumulation ("j") and coarse mode (particles between 2.5 to 10 μm represented by letter "k") (Equation 1).
- Table 3 shows species aggregation to evaluate PM_{10} components in CMAQ simulations.

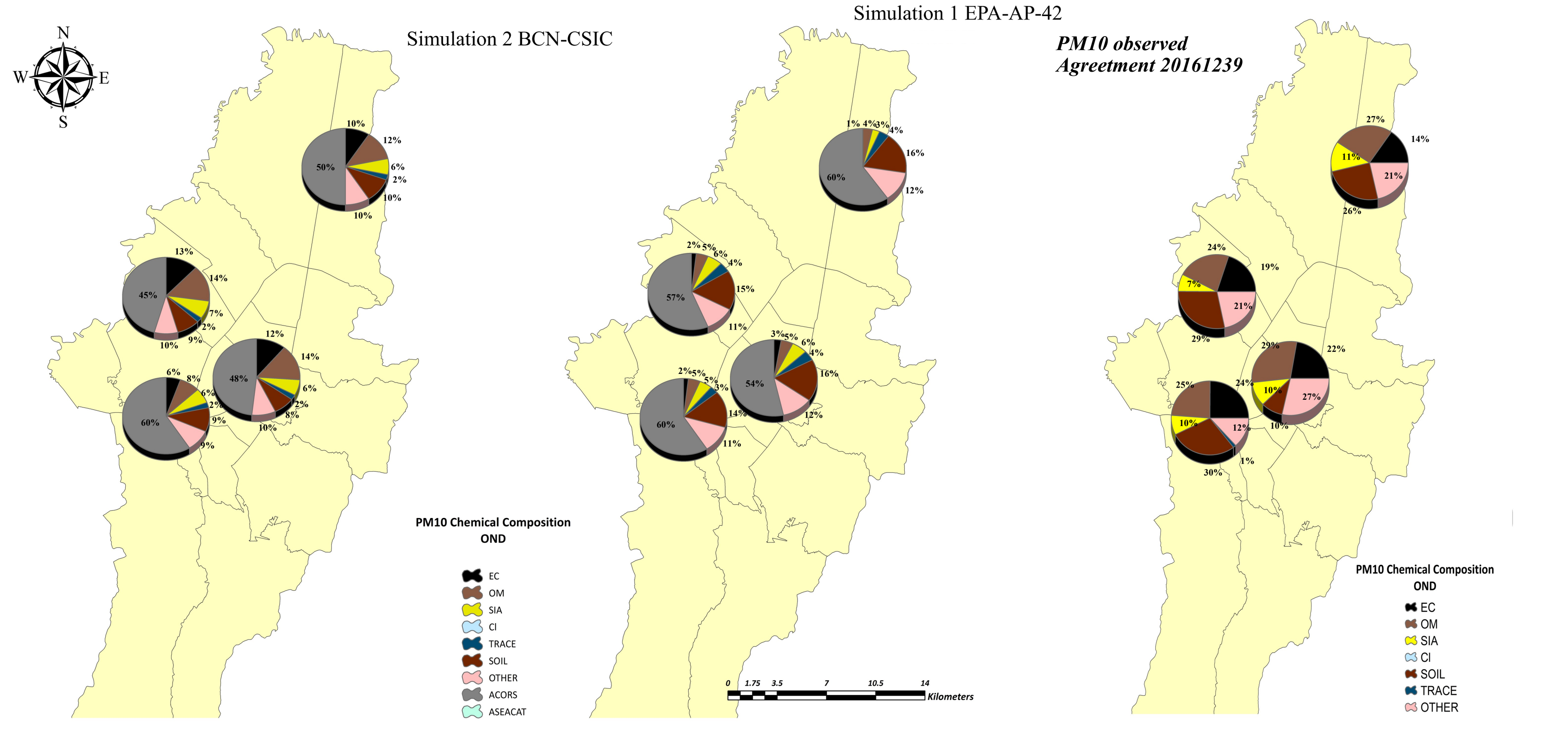


Figure 4. Chemical composition for simulated PM_{10} in representative zones of the city (season OND): A) CSIC approach for paved roads RPM emissions; B) EPA-AP-42 approach for paved roads RPM emissions. Comparison with observed PM10 chemical characterization for Bogota (Agreement 20161239)

- Although the CSIC approach leads to lower PM10 model performance, it better represents the chemical composition of PM10 for EC and SIA, according to recent studies (Figure 4) (SDA & ULS, 2017).
- SOIL components decrease in Simulation 2, allowing to observe large percentages of EC, OM and SIA.
- For both simulations, ACORS (PMcoarse unspeciated) is found the largest constituent of simulated PM10. However, ACORS decreases in most of the sites in simulation 2.
- The EPA-AP-42 approach leads to lower contributions of EC and OM to PM10 in model simulations.

Conclusions

- PM10 underestimation trends were observed when applying the CSIC approach to estimate RPM emissions from paved roads.
- Timing of RD10 sampling may have contributed to underestimation at some sites in the city, impacting the performance of the CSIC-based simulation.
- Further evaluating chemical composition will allow improved assessments of simulations under both RPM emissions approaches.
- The BCN-CSIC-based simulation showed closer representation of chemical composition relative to that previously reported for PM10 in Bogota (Figure 4).
- The EPA-AP-42-based simulation overestimated PM_{10} in the night hours. The first 3 modeled layers were averaged to avoid overestimation (ECP & ULS, 2016).

Future work

- Evaluate strategies to speciate ACORS in CMAQ.
- Further assess PM2.5 chemical composition in simulations.
- Improve temporal representation of RD10 in the estimations of RPM emissions.

Acknowledgments

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