AIR QUALITY MODELING AS A TOOL FOR ADJUSTING EMISSION INVENTORIES

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Acuerdo de Cooperación No. 02 Ecopetrol – Universidad de La Salle

Aunar esfuerzos para el desarrollo de actividades científicas y tecnológicas en el área de calidad del aire

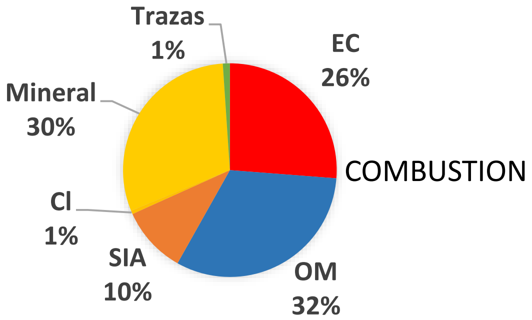
Caracterización química especializada de material particulado para la ciudad de Bogotá

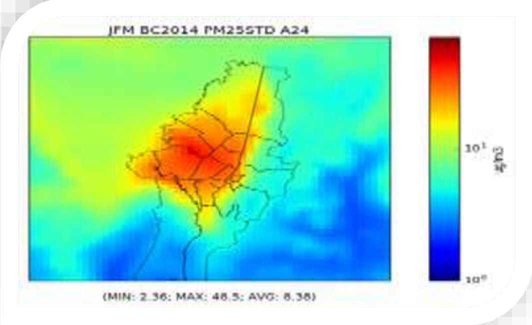
Modelación Fuente-Receptor

Modelación Fotoquímica

Auditorio (Jueves 14:45 – 15:00)
James East

PM10 INMISIÓN





CEC G2 (Viernes 9:45 – 10:00)
Jorge Pachón

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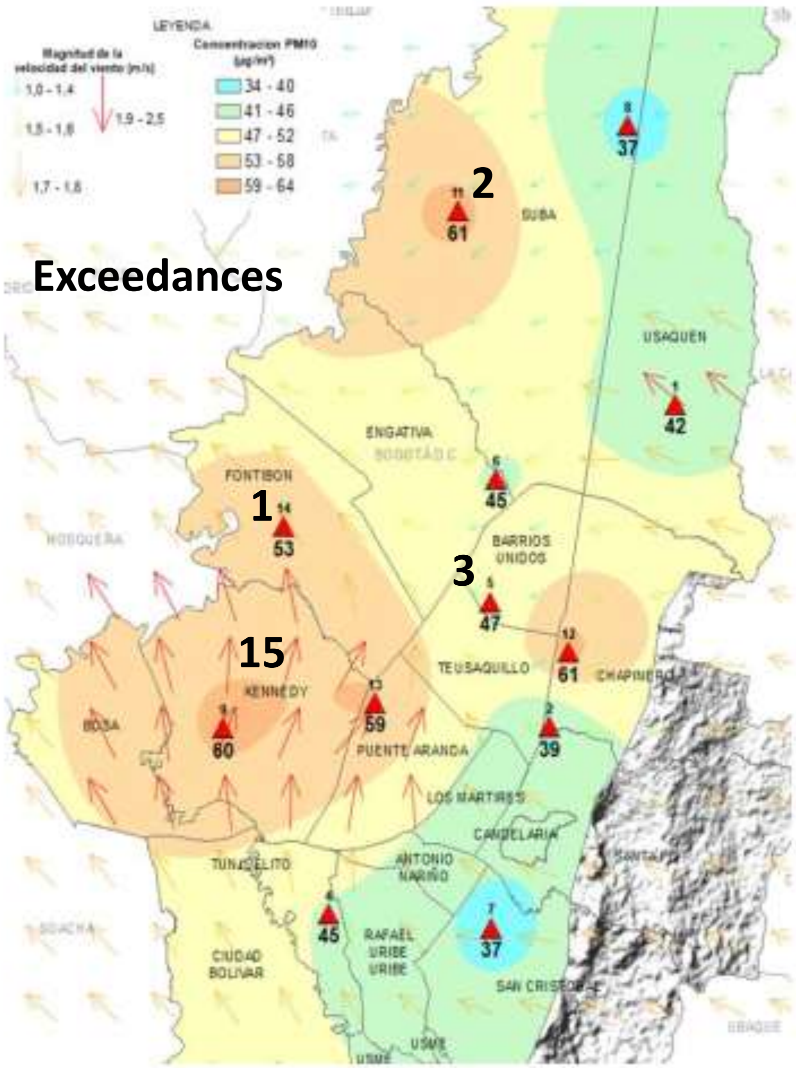
Bogota Air Quality

- Air pollution is big concern in Colombian cities where PM concentrations frequently do not meet air quality standards.

- Bogota keep having PM10 high concentrations in some sites of the city.



(SDA, 2019)

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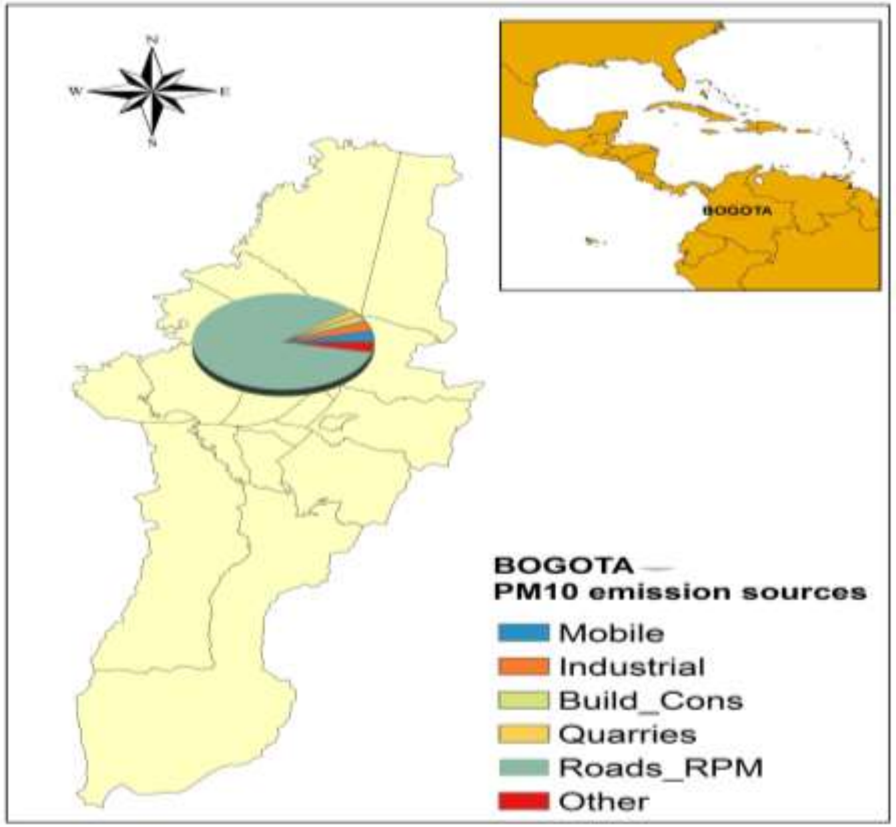
Bogota Emission Inventory (EI)

- Bogota emission inventory (EI) shows resuspended particulate matter (RPM) from paved and unpaved roads as the largest fraction of PM emissions.

- Previous air quality modeling exercises show poor PM10 performance due to overestimation of RPM emissions created using US-EPA-AP-42 methods.

(Pachón et al., 2019)



RPM emissions from roads

(Méndez et al., 2017)

EIs and Modeling

Strategy to improve air quality → Creation and evaluation of EIs

- Efforts to improve local and regional EIs around the world
- Air quality models as a tool to evaluate EIs and identify biases in observed versus modeled concentrations.

→ Develop emission reduction strategies

Use of models

Impacts of updated VOC emission estimates and spatial surrogates were evaluated by modeling O3 concentration. CMAQ	Yin et al. (2015) China
The comparison of the total ammonia emissions → VOLT'AIR_INS and standard emissions EMEP. CHIMERE model	Hamaoui-Laguel et al. (2014) France
PM2.5 comparison approach with multiple source apportionment methods → Identification of large biases by sector. PMF vs CMAQ	Uranicshi et al. (2017) Japan

1. Updating Bogota EI (2014)

New method to estimate RPM emissions from paved roads in the PM_{10} EI by applying a novel methodology developed by the Spanish Research Council (CSIC).

Features	EPA AP-42 (Pachón et al., 2018)	CSIC (Amato et al., 2009)
Sampling equipment	- Industrial vacuum cleaner - Sweep kit (Brush and dustpan)	- CSIC road dust sampler
Sampling flow	60-120 LPM	30 LPM
Sampling area	1.7 m^2	1 m^2
Particle size	PM less than 75 µm	PM less than 10 µm

RPM emissions from paved roads (Bottom-up)

$$FE = a * (RD_{10})^{\text{Exp}^{b}}$$

RD10 = road dust (< 10 µm) (µg/m2)

PM10			
Constantes de la Ecuación			
a	45.9	b	0.81

(Amato et al., 2011)

$$E = FE * FA$$

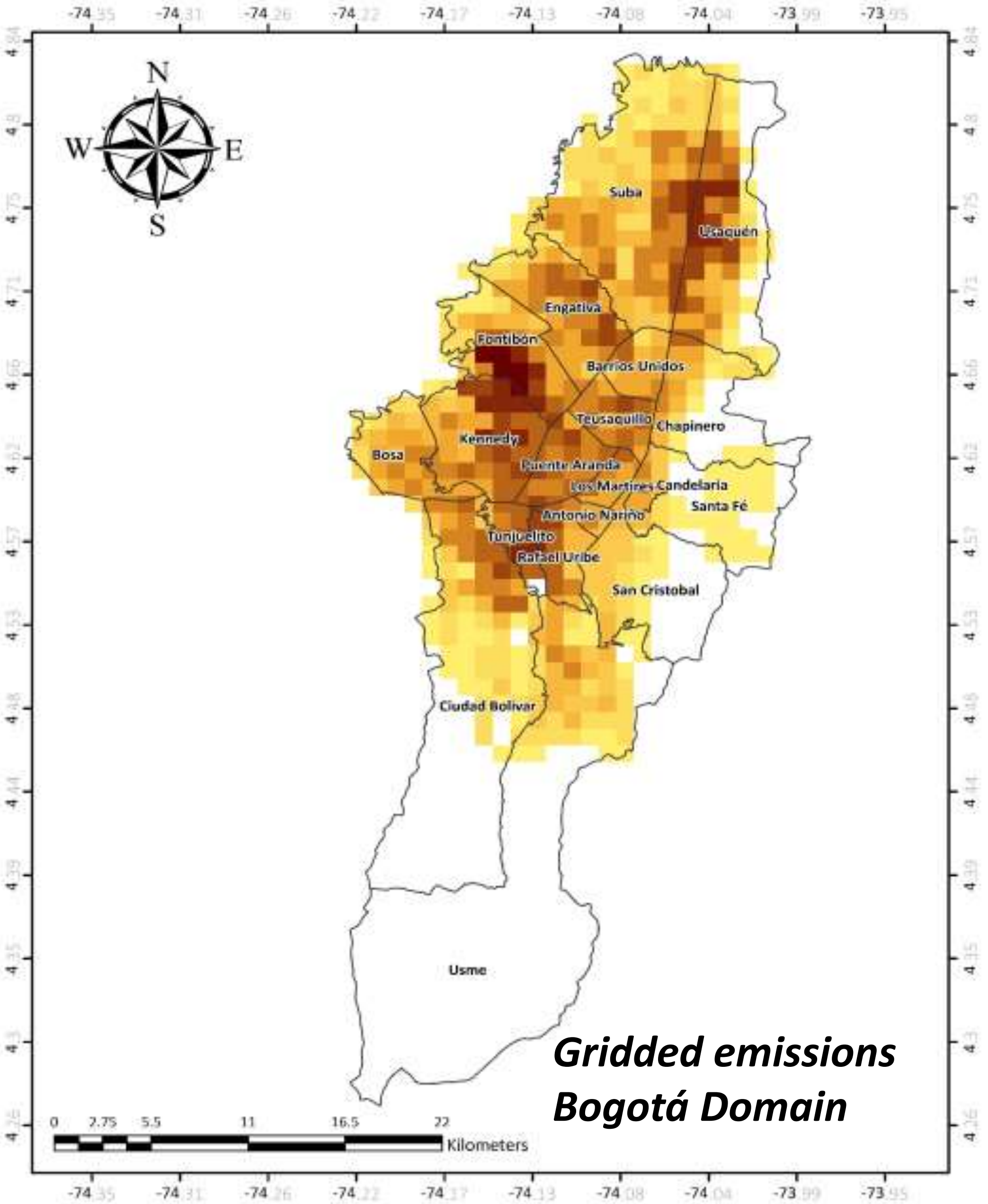
Where:

E = emission

EF = emisión factor (g /VKT)

FA = Activity factor (VKT)
Lane length * vehicle flows

Emission estimation



Gridded emissions Bogotá Domain

Bogota EI (Updated)

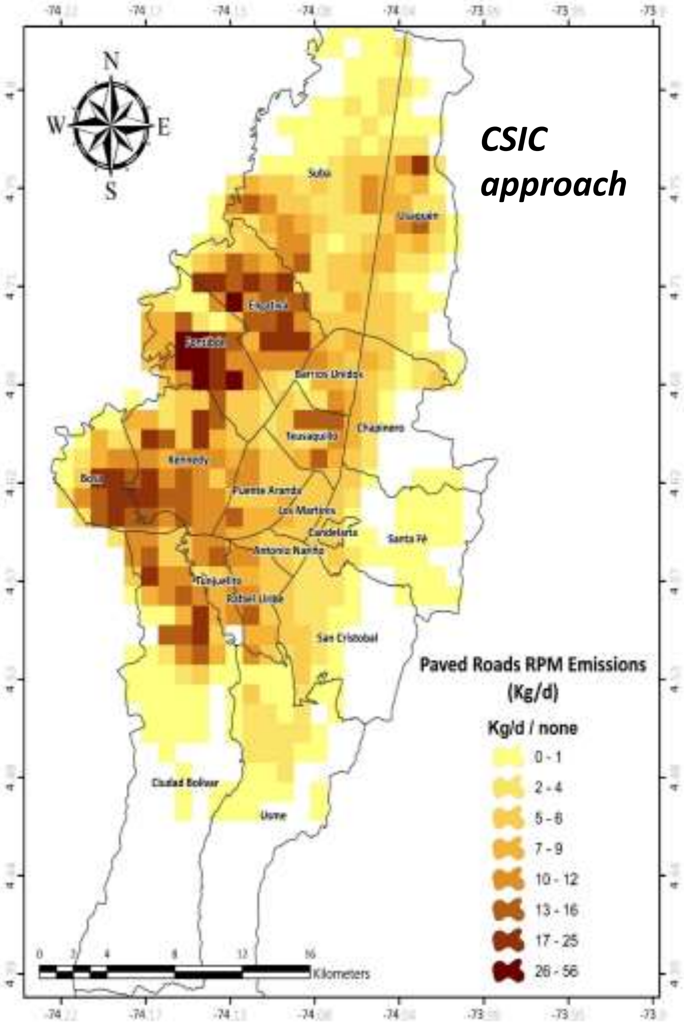
- Reduction of 97% of PM_{10} emissions (paved roads RPM) is estimated applying CSIC approach.
- The reduction in emissions in the EI is 37% when emissions from all sectors are considered.

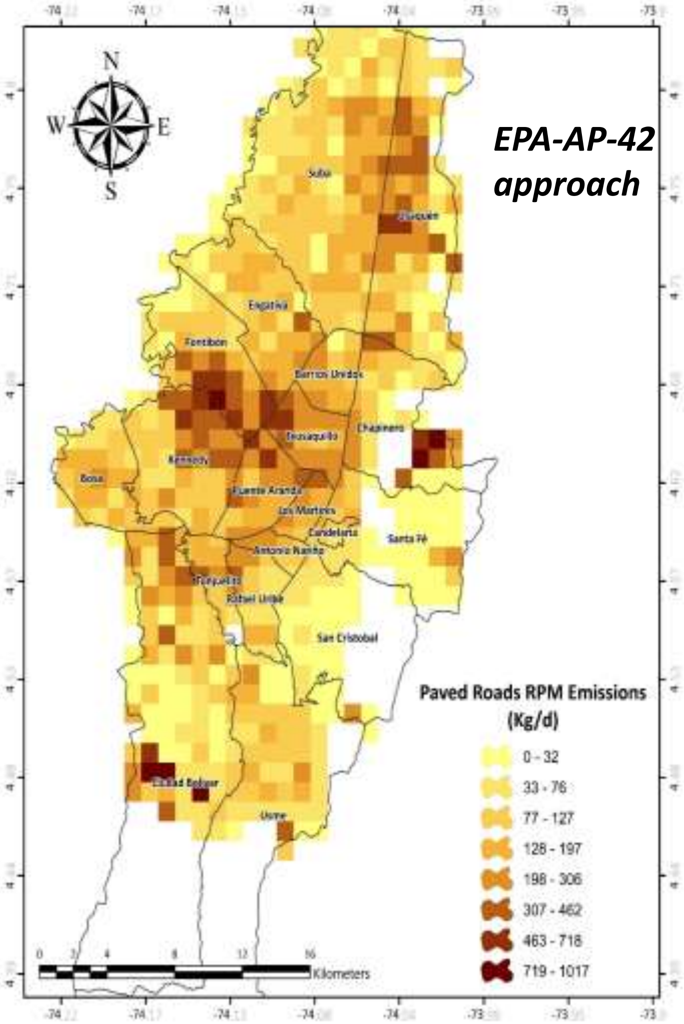
Bogotá PM_{10} emissions inventory (2014)				
Source	Paved roads RPM CSIC approach		Paved roads RPM EPA-AP-42 approach	
	kg/d	Contribution (%)	kg/d	Contribution (%)
Point	5,964	8%	5,964	5%
Mobile	7,337	9%	7,337	6%
RPM paved roads	**5,025**	**6%**	**51,085**	**41%**
RPM unpaved roads	52,627	68%	52,627	43%
RPM other sources[1]	6,496	8%	6,496	5%
Total	***77,449***		***123,509***	

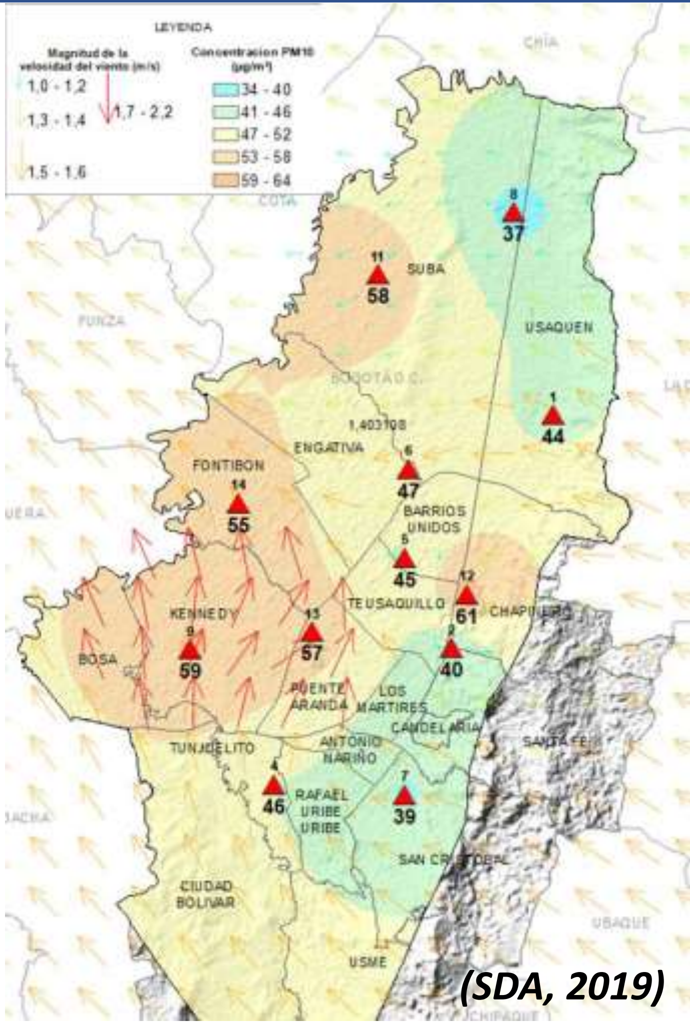
Mobile → Ramirez et al. (2019) MOVES EF

RPM unpaved roads → Perez et al. (2017) Natural mitigation factor

Spatial Assessment → PM10 emissions







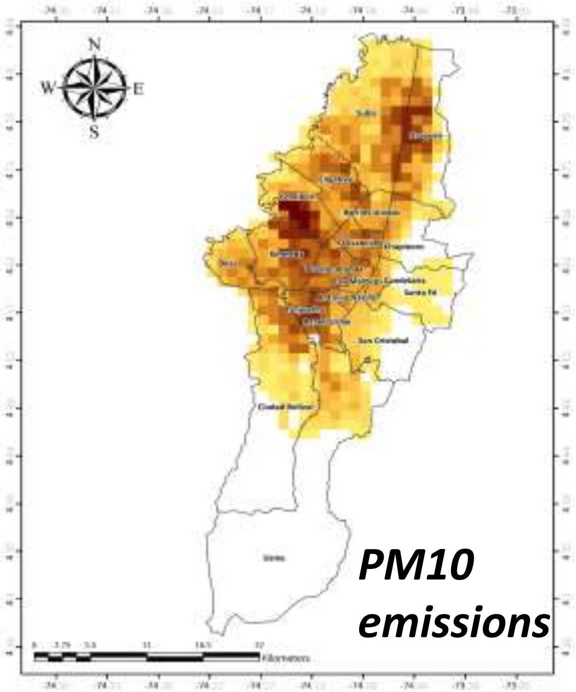
(SDA, 2019)

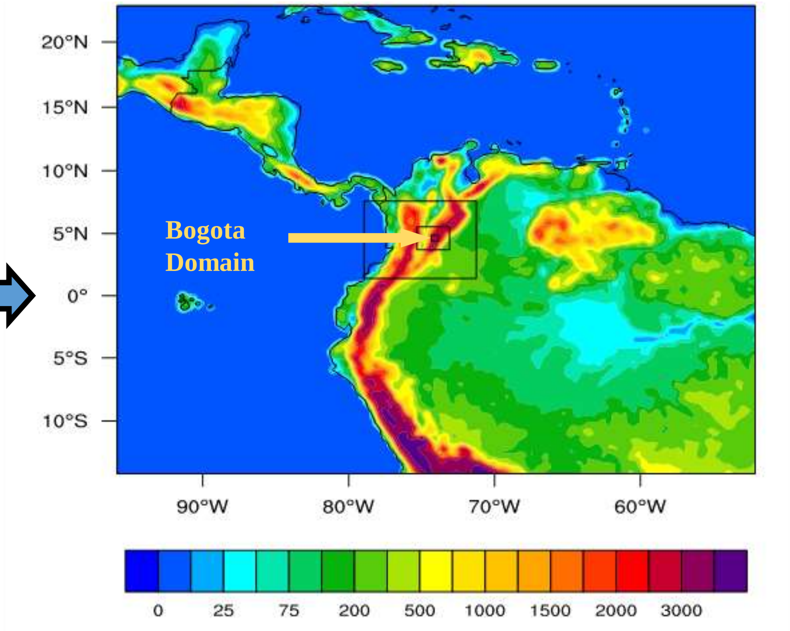
❖ *Qualitative analysis*

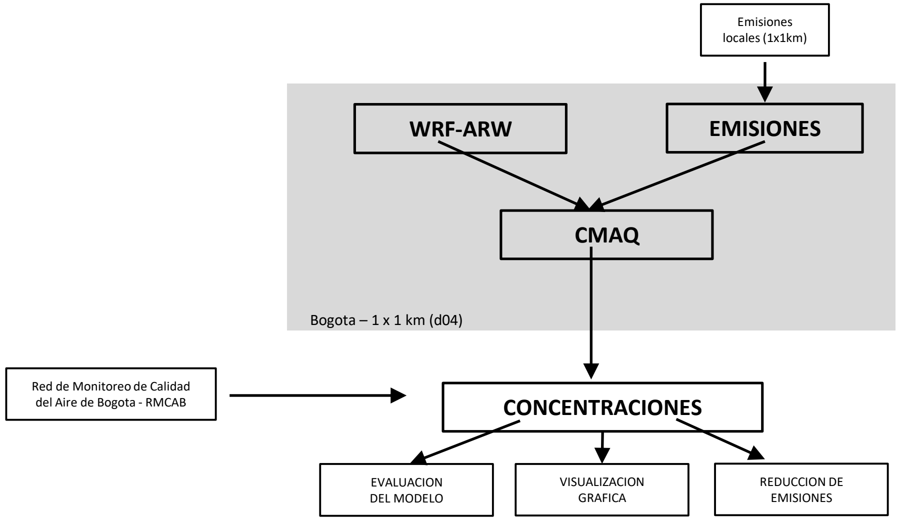
CSIC approach → Better spatial distribution was found comparing with PM10 ambient levels

2. Air quality Modeling using CMAQv5.0.2

Domain	Four increasingly resolute domains. Model runs use 64x64 km at 1 km resolution over Bogota, Colombia
Emissions	Two emission inventories changing PRD RPM emissions
Chemical Boundary Conditions	Developed with GEOS-Chem and provided to coarsest domain (total extent above)
Meteorology	2014 meteorology developed by Nedbor-Gross et al. (2017) (WRF)
Simulations	2 season, JFM (Dry) & OND (Wet), 180 days total







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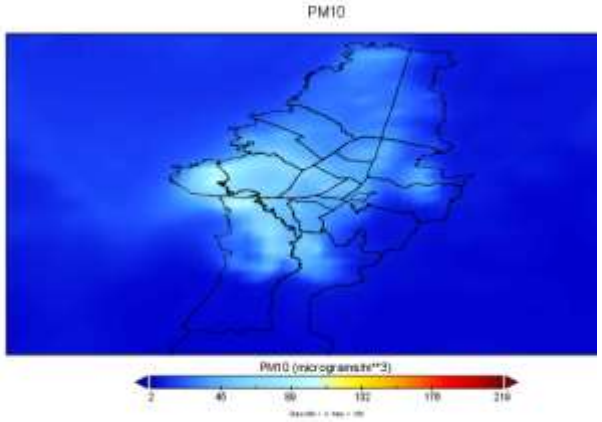
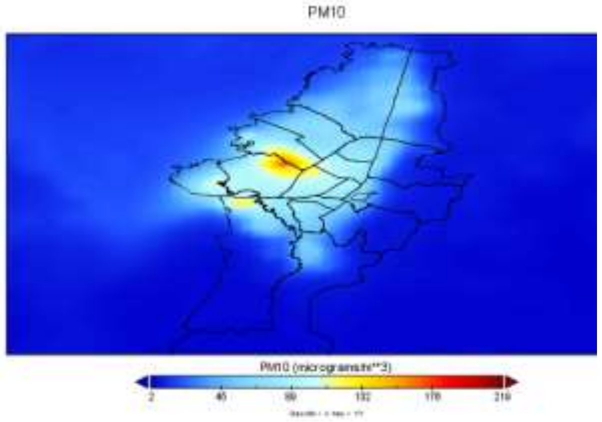
Modeling results assessment

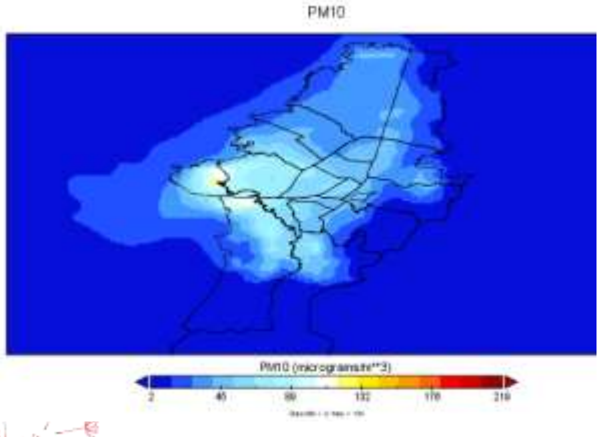
a) PM_{10} modeled using paved roads RPM CSIC approach (JFM)



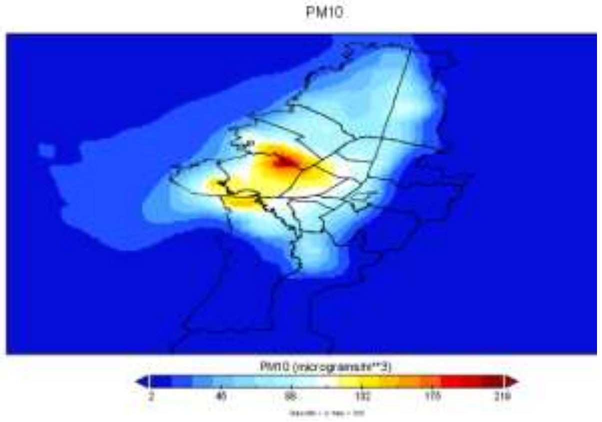
b) PM_{10} modeled using paved roads RPM EPA-AP-42 approach (JFM)



c) PM_{10} modeled using paved roads RPM CSIC approach (OND)



d) PM_{10} modeled using paved roads RPM EPA-AP-42 approach (OND)



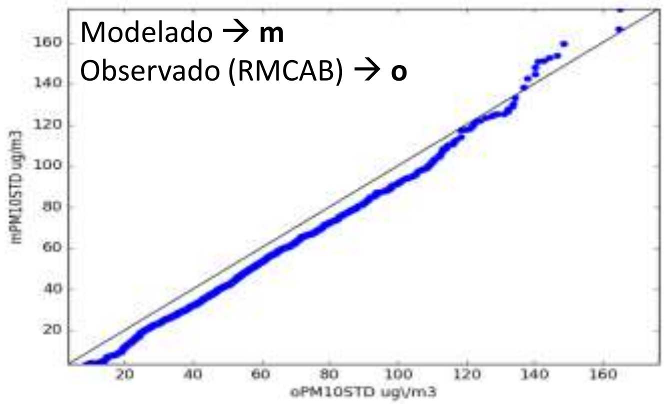
Bogotá PM_{10} modeled concentrations ($\mu g/m^3$) (2014)						
City Zone	Paved roads RPM CSIC approach		Paved roads RPM EPA-AP-42 approach		Reductions (%)	
	JFM	OND	JFM	OND	JFM	OND
North	20.7	25.3	34.0	48.3	-39%	-48%
West	39.6	44.9	79.5	59.0	-34%	-33%
Southwest	56.8	70.0	85.8	104.1	-50%	-24%
Center & East	39.1	45.3	75.2	106.8	-48%	-58%
Overall	***39.0***	***46.4***	***68.6***	***79.6***	***-43%***	***-42%***

The highest concentrations for both emission estimation methods occurs in the wet season (OND).

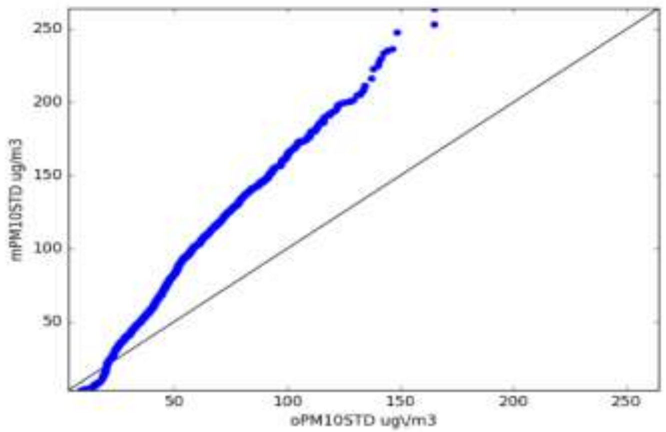
Concentrations in the southwest zone for JFM and Center-East for OND are highly sensitive to the change in RPM emissions estimation method.

Metrics assessment

OND/WET (October, November, December) 2014



CSIC-Approach
77 Ton/day



EPA-AP-42-Approach
123 Ton/day

❖ *Q-Q analysis*

CSIC approach → better 1-1 behavior comparing modeled vs observed concentrations

EPA-AP-42 approach → overestimation trends for both seasons

❖ Lower biases are founded with CSIC approach

MFB

$$MFB = \frac{1}{N}\sum_{i=1}^{N}\frac{(C_M - C_O)}{\left(\frac{C_O - C_M}{2}\right)}$$

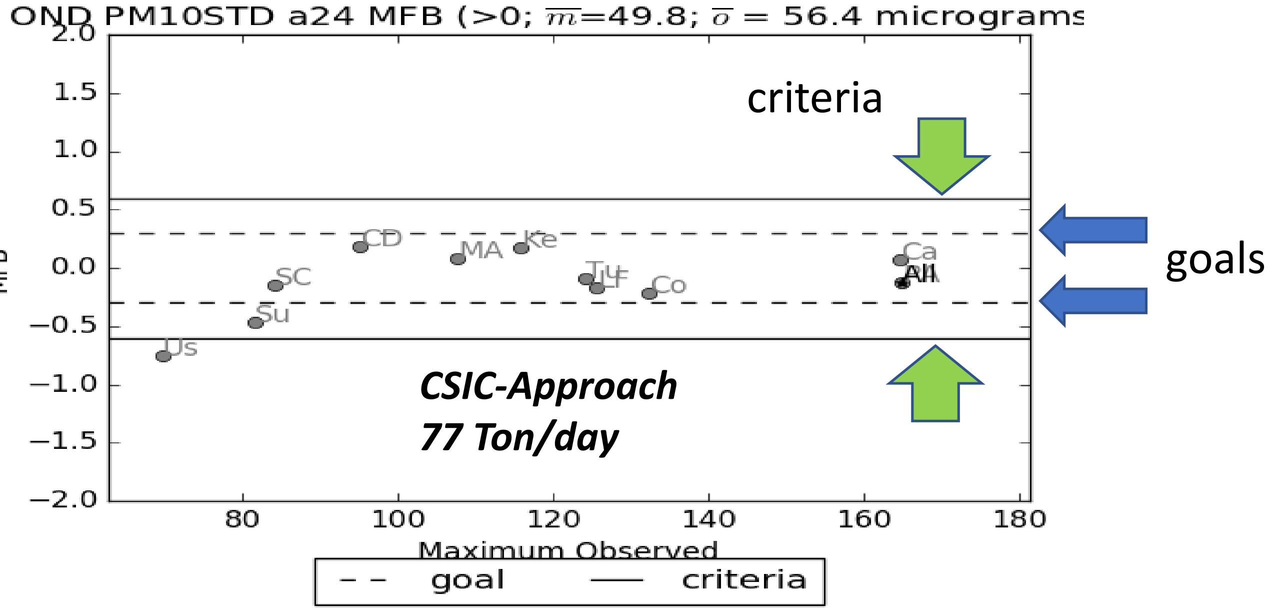
PM_{10} Metrics	Paved roads RPM CSIC approach		Paved roads RPM EPA-AP-42 approach	
	JFM	OND	JFM	OND
MFB	-19%	-3%	31%	50%
MFE	42%	34%	50%	57%

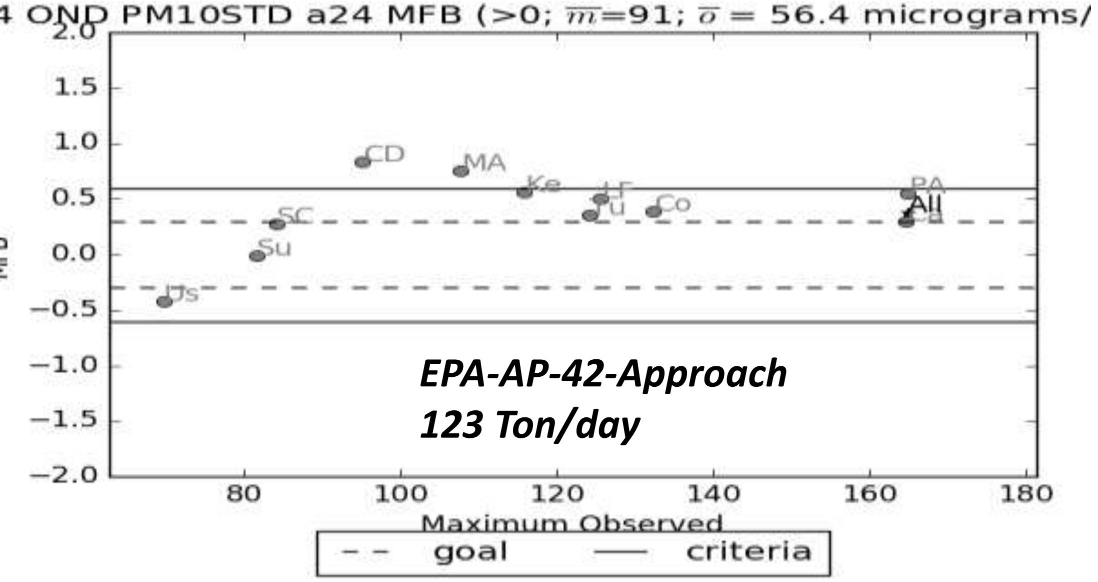
Boylan & Russell (2006) goals and criteria

METRICS	GOAL	CRITERIA
MFB	± 30%	± 60%
MFE	50%	75%

❖ CSIC simulation agrees well with observed PM_{10} concentrations based on the average of monitoring stations, especially for OND.

Metrics assessment





Applying metrics in different sites allows to identify areas with low bias

→ Overestimation or underestimation trends

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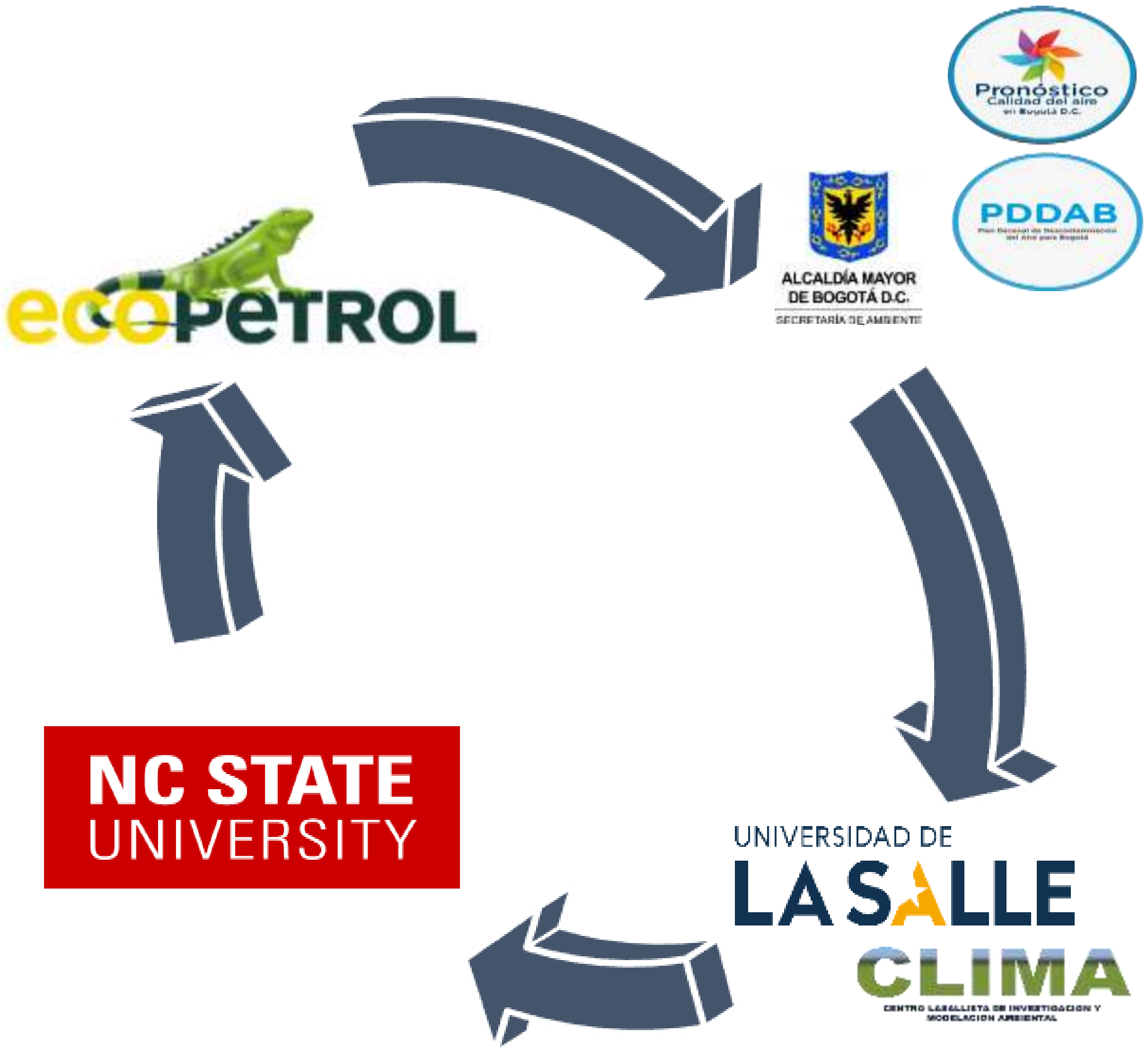
Conclusions

- CSIC approach presents a reduction of 37% of PM_{10} total emissions.
- Better model performance with lower biases was found using CSIC approach.
- The methodology based on a model performance evaluation establishes a tool for evaluation and adjustment of EIs (Spatial and temporal).

Acknowledgment



Thank you!
Gracias!