Integrating Speciated Particulate Matter Data to Improve Model Performance in Bogota

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Motivation

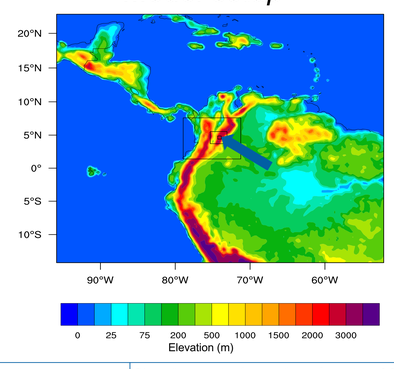
Bogota, Colombia, a city of 8.5 million people, frequently exceeds the coarse and fine particulate matter (PM_{10} and $PM_{2.5}$) daily standards. Air quality modeling has been conducted for the past three years (Nedbor-Gross, Henderson, Pérez-Peña, et al., 2017); however, lack of chemically speciated PM measurements has been a barrier to PM model evaluation. Recently, a network of ground-based PM measurements was set-up and now provide information on the concentrations of PM and the chemical species from five unique sites across the city (Ramirez et al., 2018). Speciated PM observation data will aid in improving model performance by allowing better calibration of local coarse mode aerosol emissions to complement the emissions inventory developed by Pachon et al. (2018).

Objectives

1. Compile, benchmark, run, and evaluate mass-based and speciated PM_{10} model performance for simulations over Bogota, Colombia using CMAQv5.0.2 and all requisite libraries.
2. Improve coarse mode aerosol emissions by altering CMAQ emissions processing to speciate coarse mode aerosol, using results to update coarse emissions profiles.
3. Develop strategies for improving model performance in other regions where modelling is desired but speciated or observed data is limited, using Bogota as a case study.

Methodology

Model setup



Domain	Four increasingly resolute domains. Model runs use 64x64 km at 1 km resolution over Bogota, Colombia (smallest domain shown)
Emissions	Local inventory developed by Pachon et al. (2018)
Chemical Boundary Conditions	Developed with GEOS-Chem and provided to coarsest domain (total extent above)
Meteorology	2014 meteorology developed by Nedbor-Gross, Henderson, Davis, et al. (2017)
Simulations	2 season, JFM & OND, 180 days total

Observations

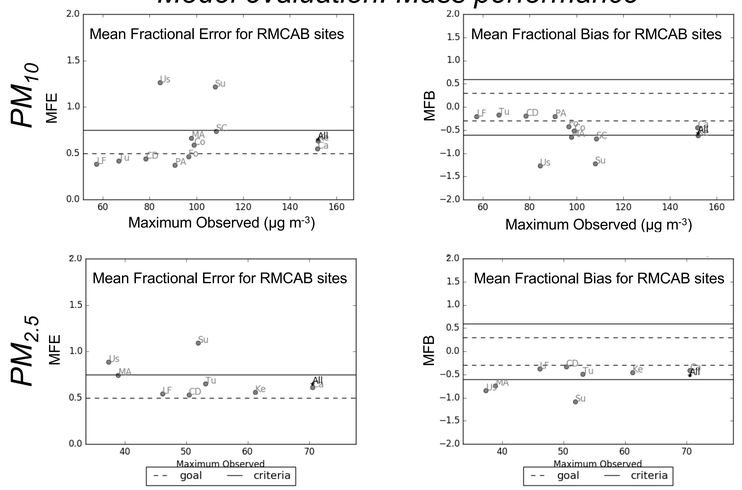
Observed Data

Data source	Sites	Form	Availability	Species
Government RMCAB network	14	24-hour average	Every day	Mass only
Universidad de La Salle	4	24-hour average	16 days in April and May 2017	EC, OM, NO_3^-, SO_4^{2-}, NH_4^+, Cl^-, Mineral, Trace
Ramirez et al. 2018	1	24-hour average	Daily from June 2016 to May 2017	EC, OM, PO_4^{3-}, NO_3^-, SO_4^{2-}, NH_4^+, Cl^-, Mineral, Trace

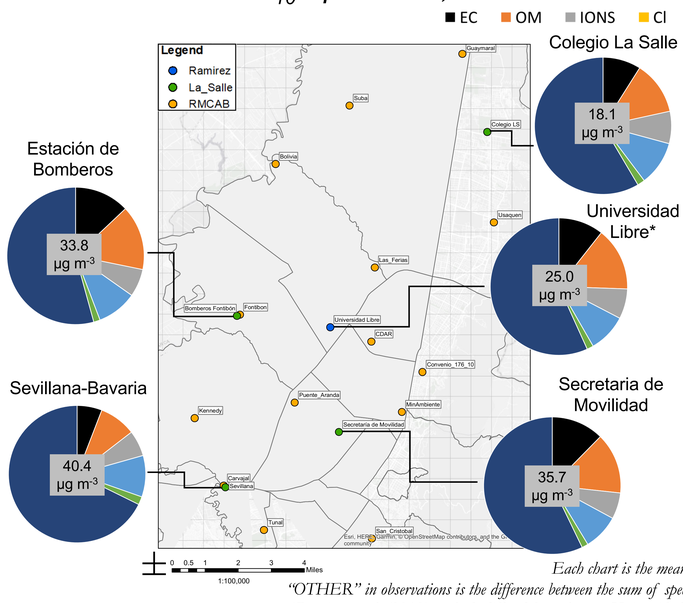
Only JFM data are displayed. For the Ramirez et al. 2018 data, OM value was obtained using 2.1×OC.

Results

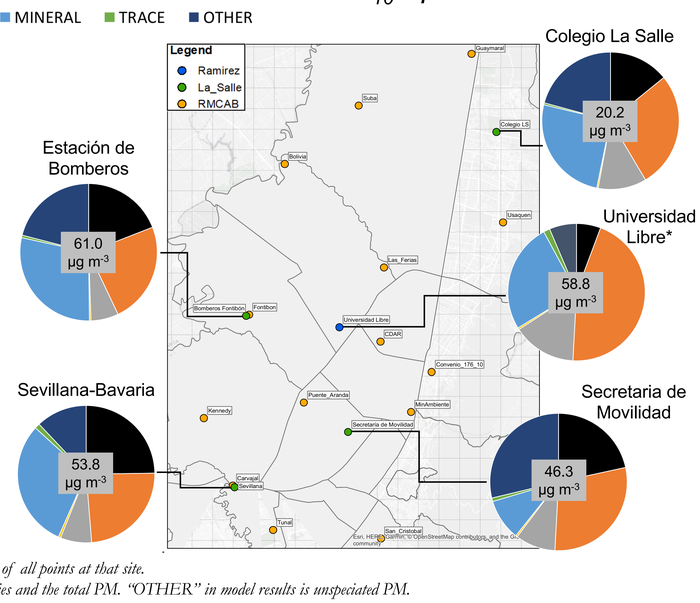
Model evaluation: Mass performance



Modeled PM_{10} Speciation, JFM Mean



Observed PM_{10} Speciation



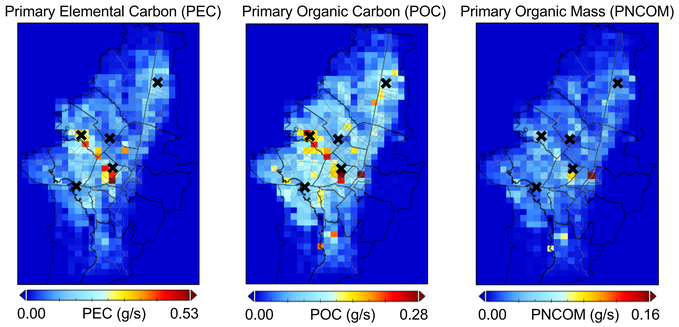
Each chart is the mean of all points at that site.

"OTHER" in observations is the difference between the sum of species and the total PM. "OTHER" in model results is unspeciated PM.

**Ramirez et al. (2018) methods differed from those at Universidad de La Salle sites. Species have been aggregated into matching categories.*

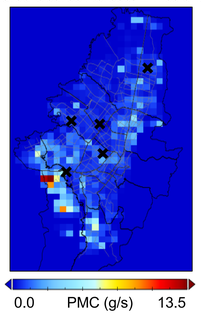
- MFE and MFB were calculated at RMCAB sites for PM_{10} and $PM_{2.5}$ mass. Rigorous calculations for species were not performed due to data sparsity.
- In the mean of all cases, the criteria are met, indicating the model's fitness for characterizing air quality. Not all individual sites meet MFB and MFE criteria.
- Several sites which show large negative bias in $PM_{2.5}$ show small negative bias in PM_{10}, indicating **good or overestimation of coarse-mode aerosol mass (PM_{10} minus $PM_{2.5}$) by the model**.
- Total PM_{10} mass is underestimated compared to speciated measurements
- Colegio La Salle, an urban background site, closely matches observed mean PM_{10} mass.
- Mass is underestimated at Sevillana and Bomberós. Resuspended particulate matter (RPM) is emitted in these areas; errors in temporal representation of RPM emissions could contribute to model underestimation.

Average JFM Fine PM Emissions



- PEC and POC emissions are highest near the Estación de Bomberos and Secretaria de Movilidad sites. In the model, this is reflected in the speciated fractions.
- In the observations, higher fractions of EC, OM, and Mineral matter are observed at Sevillana that are not reflected in the model.
- High OM fraction is observed at Movilidad and not reflected in the model simulation.

Average JFM Coarse PM Emissions



- Average **PMC emissions are highest adjacent to the Sevillana** site, reflected in the high fraction of unspeciated PM at that site. Model simulated coarse aerosol is unspeciated, preventing a rigorous analysis of species performance.
- The **Mineral fraction of PM_{10}**, an indicator of resuspended dust, is **underestimated at Estación de Bomberos, Sevillana-Bavaria, and Universidad Libre.**

Future Work

1. Updating emissions profiles and processing to simulate speciated coarse aerosol.
2. Developing strategies for using sparse observation data to improve model performance in other areas where speciated and observed PM data is limited or lacking.

Acknowledgements

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