Estimation of traffic-related concentrations and exposures at border crossings between the United States and Mexico

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Joint Advisory Committee

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Background

- Vehicular emissions of transportation-related air pollutants (TRAPs) at international ports of entry (POEs) are a major health concern for users and nearby residents.
- 15 to 16 million passenger cars and 750,000 commercial vehicles cross the 4 POEs between El Paso, Texas, and Cd. Juárez, Chihuahua each year.
- Prolonged wait times at POEs potentially increase users' exposure to TRAPs.
- The Bridge of the Americas (BOTA) in El Paso, Texas, has the highest volume of traffic, with 3.3 million northbound vehicles crossed from Cd. Juarez to El Paso and over 600,000 pedestrians crossing on foot in 2021.
- Limited air quality studies have been conducted at POEs due to concerns of security compromise, traffic interruption.

Objectives

This study addresses the potential air pollution impacts on the health of bridge users or POE workers as well as the residents of nearby community with three objectives:

1. Assess levels of $PM_{2.5}$, NO_2, and O_3 from vehicles at the El Paso POEs.
2. Establish PM levels in surrounding communities using low-cost sensors on both sides of the border.
3. Evaluate predicted PM levels ($PM_{2.5}$, PM_{10}, NO_2, O_3) from POE emissions and their impact on adjacent areas.

Study Design

- BOTA and various city sites for pollutant measurement.
- BOTA air sampling occurred over 34 days, from February 7 to March 12, 2022, at two car lane stations.
- Additional $PM_{2.5}$ monitoring at four El Paso schools and one Cd. Juarez location.
  - Six Purple Air sensors were installed in El Paso, with two at three locations for quality assurance, and two in Cd. Juarez due to equipment transfer delay.
- TCEQ CAMS 41 station served as a reference, situated around 60 m from Cesar Chavez Memorial Highway, for comparing with Purple Air data.

Sampling Locations and Instrumentation Setup

$PM_{2.5}$

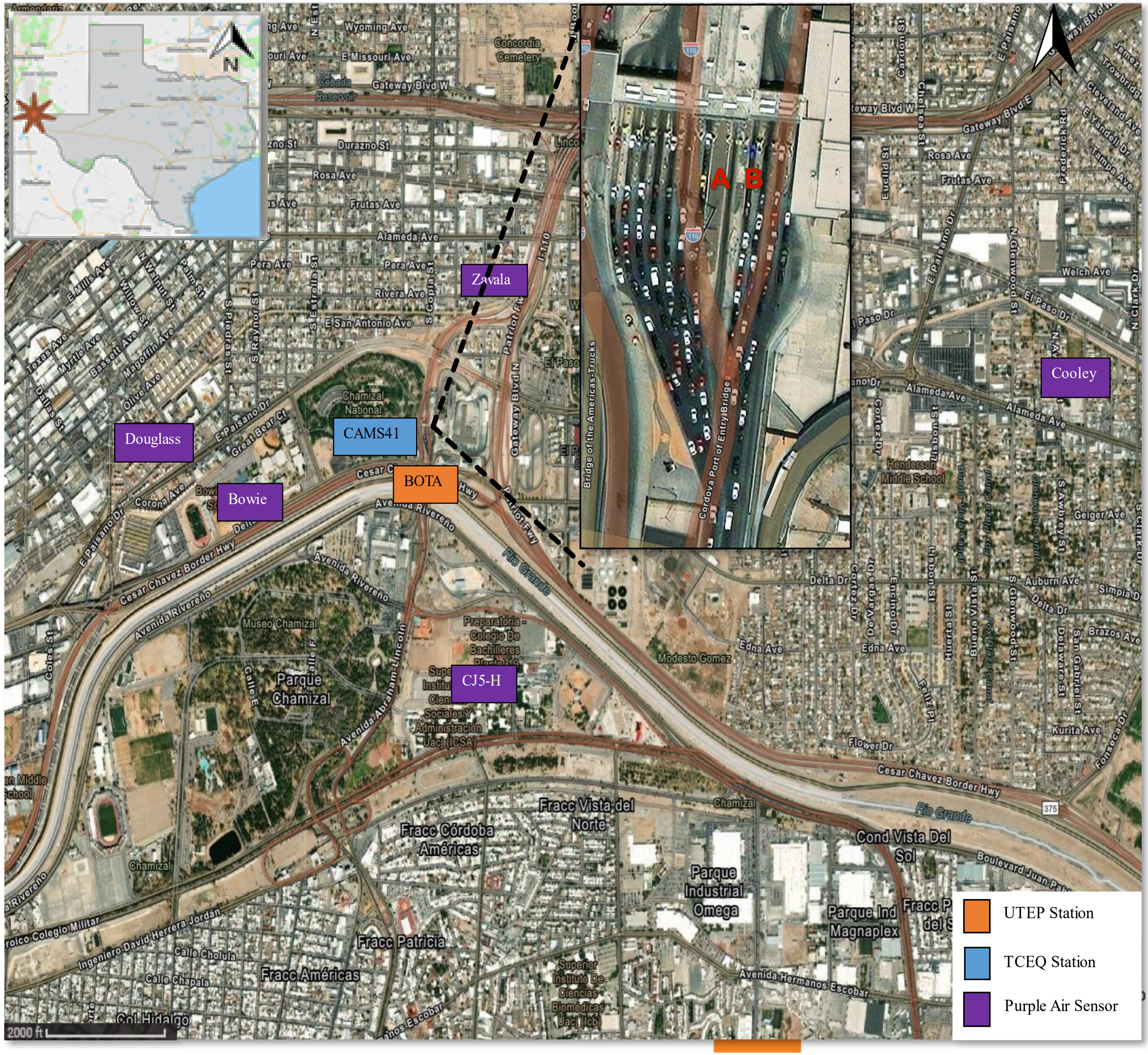
- GRIMM 11A Portable Laser Aerosol Spectrometer and Dust Monitor
- PurpleAir PA-II

O_3

- 2B Technologies Model 202 Ozone Monitor

NO_2

- 2B Technologies Model 405 for $NO_2/NO/No_x$ Monitor



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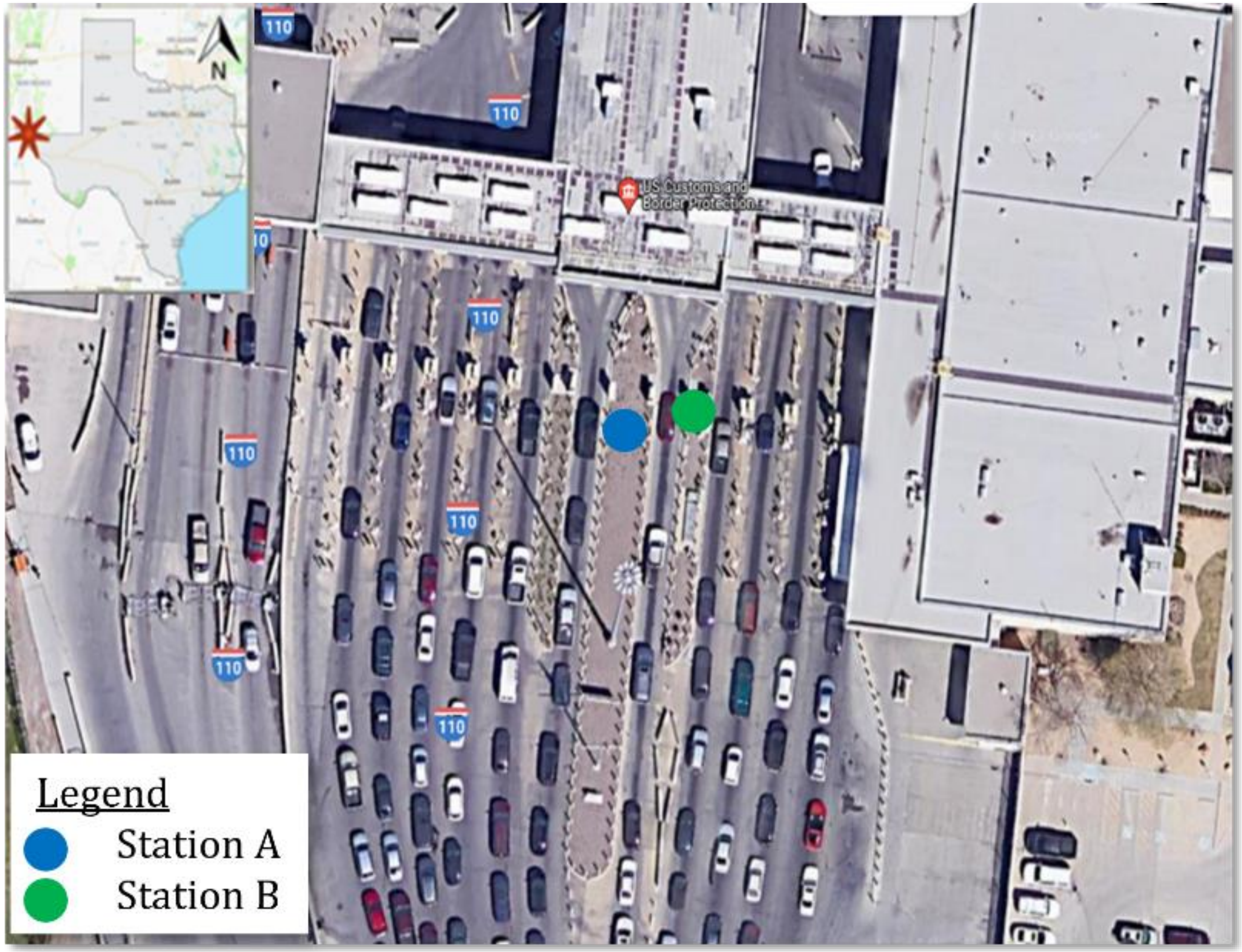
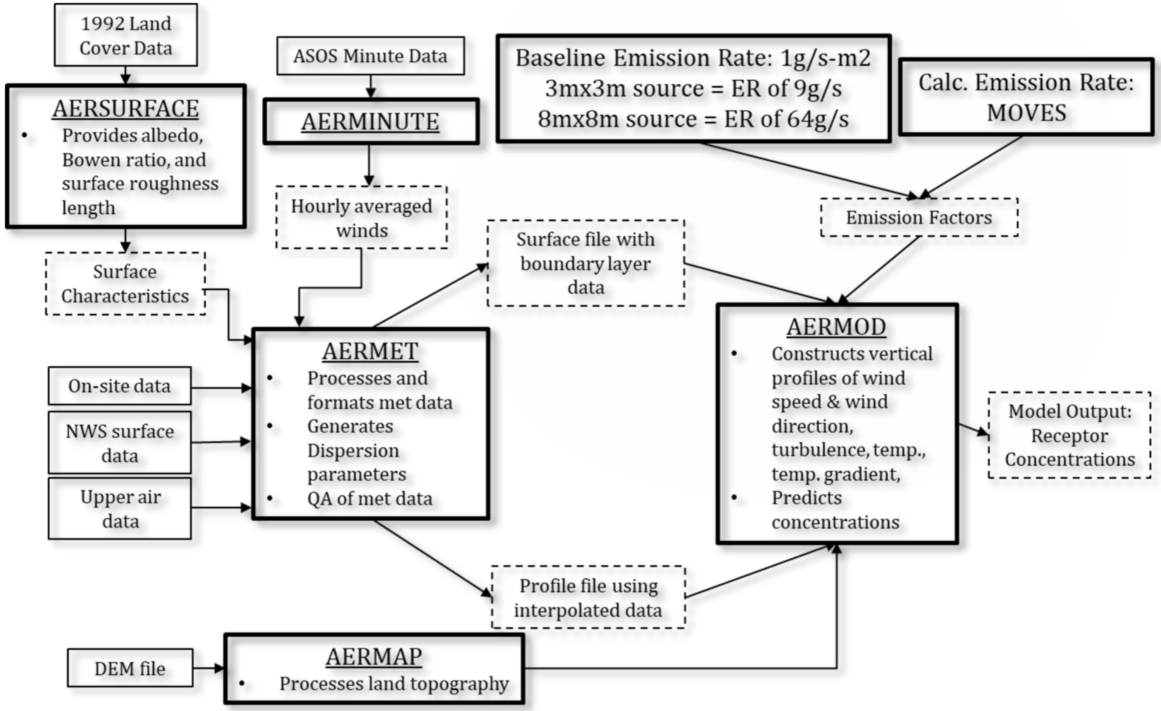
Sampling Locations and Instrumentation Setup



AERMOD Dispersion Modeling of BOTA Emissions

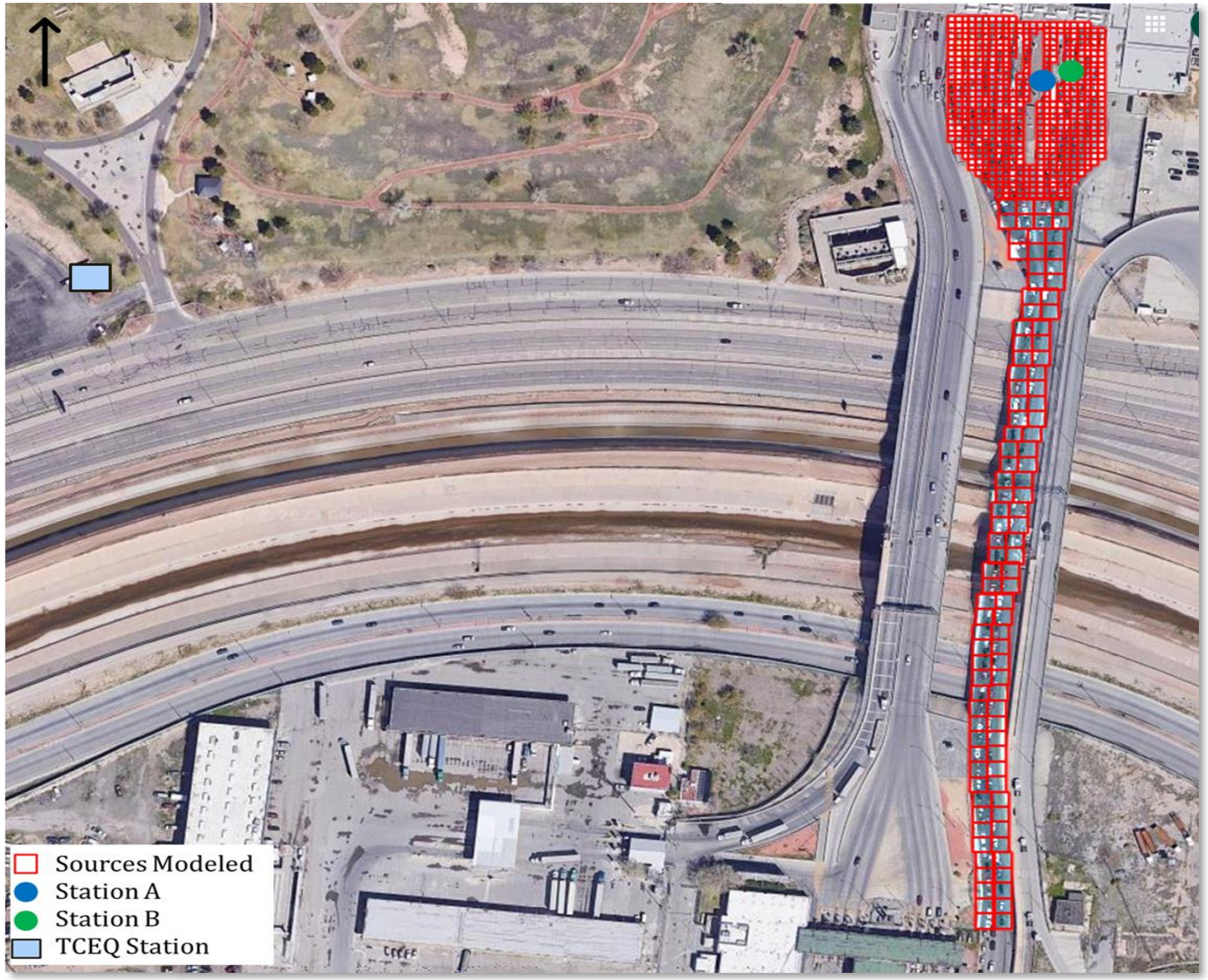
- AERMOD modeling system components include AERMET and AERMOD, using El Paso International Airport and CAMS 41 data for meteorological pre-processing.
- AERMOD modeling parameters and options include:
  - passive pollutant,
  - volume source characterization for 689 BOTA northbound lanes,
  - urban environment,
  - flat terrain, ground-level release,
  - ground-level receptor,
  - and site-specific meteorology.



Source Characterization

- Volume sources in AERMOD model emissions with a uniform distribution along roadway links.
- A series of volume sources can model roadways and queuing links, requiring a higher number of small sources for accuracy.
- The combination of small volume sources represents the physical dimensions and orientation of roadway links in detail.
- The model used a combination of 587

3-m × 3-m and 102 8-m × 8-m wide volume sources for representation.



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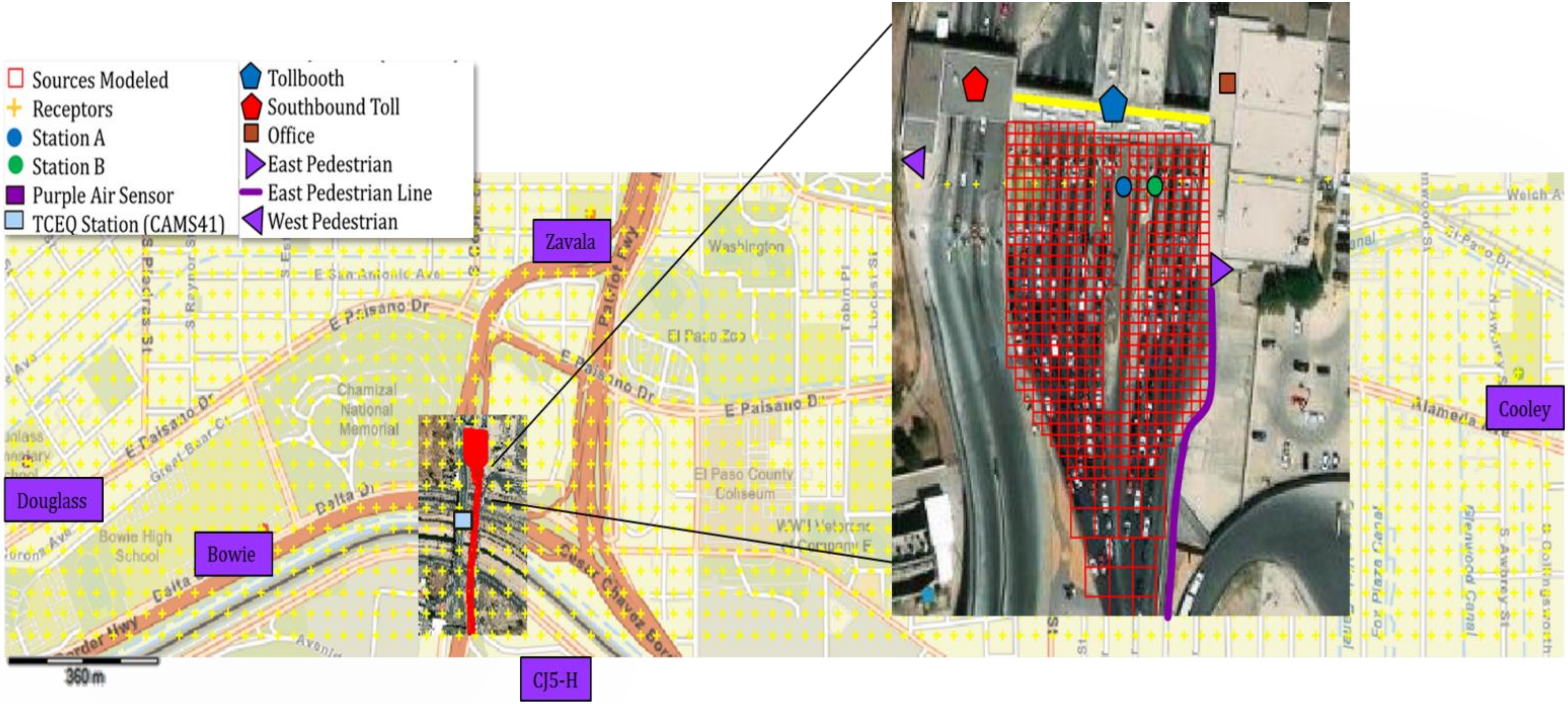
Receptor Selection



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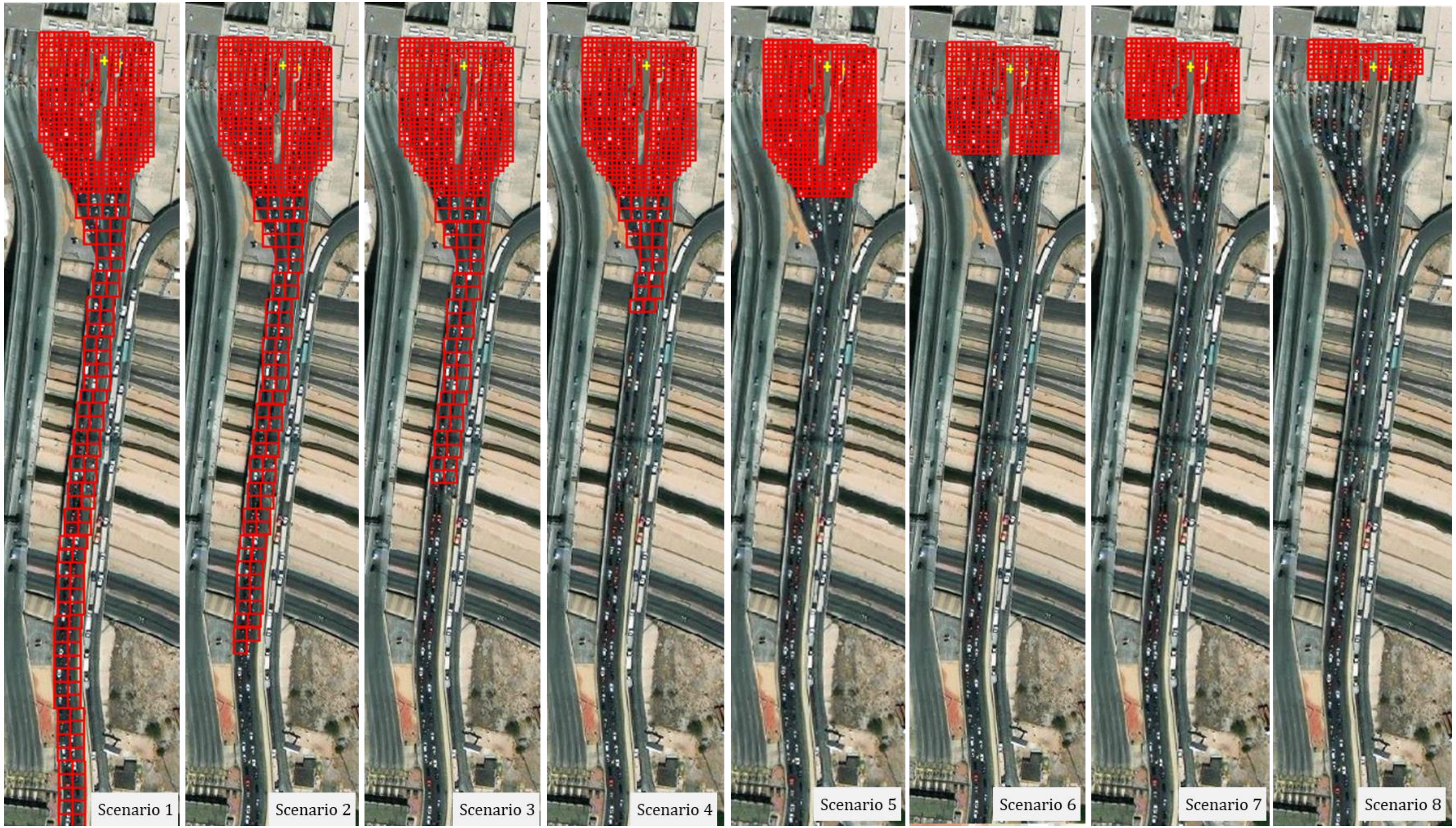
Modeling Scenarios

- Multiple analyses were conducted to test the impact of queue length
- The queue length was reduced by decreasing the number of sources.
- Scenario 1, the base run, had a queue length of 480 m with 100 percent of all volume sources modeled.

Scenario Number	Queue Length (m)	Number of Sources	% of $(3m)^2$ Sources	% of $(8m)^2$ Sources
Scenario 1	480	690	100	100
Scenario 2	370	662	100	75
Scenario 3	270	637	100	50
Scenario 4	165	611	100	25
Scenario 5	90	587	100	0
Scenario 6	70	450	75	0
Scenario 7	45	293	50	0
Scenario 8	24	147	25	0

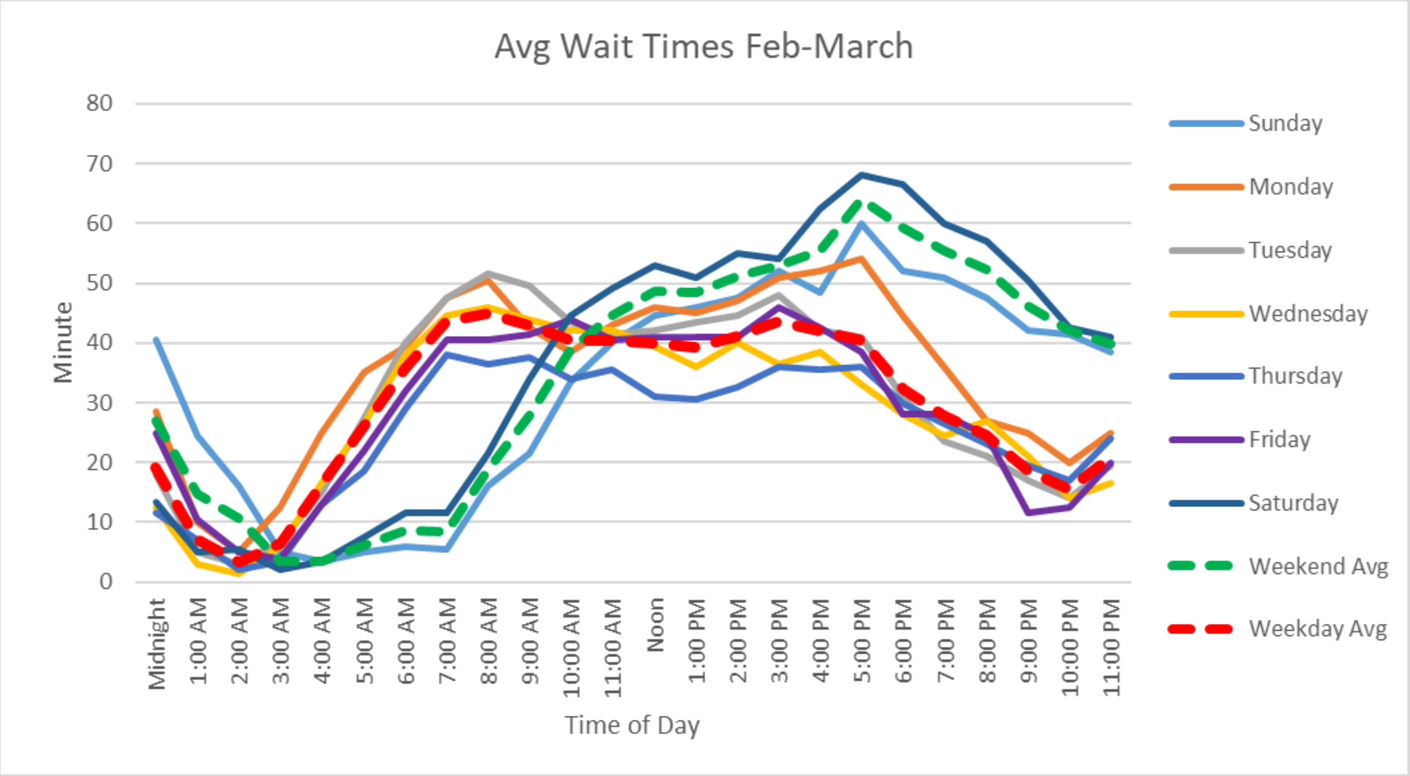
Modeling Scenarios



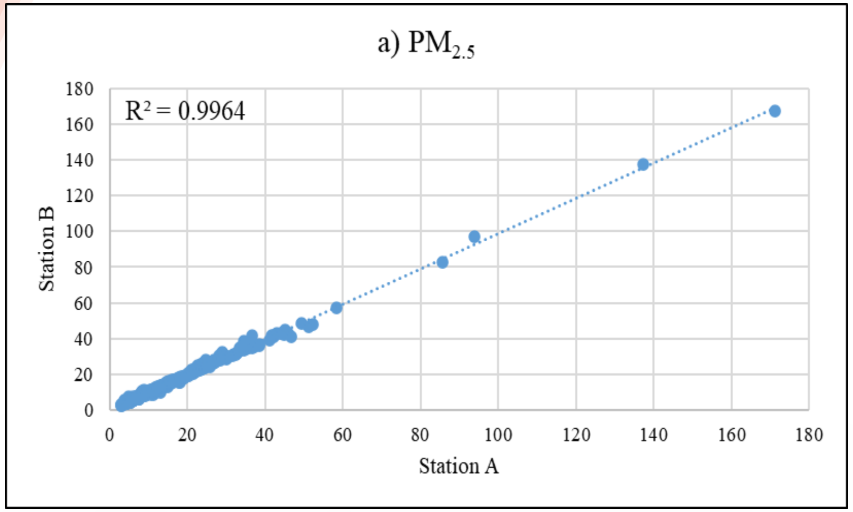
Emission Rates Calculations & Analysis

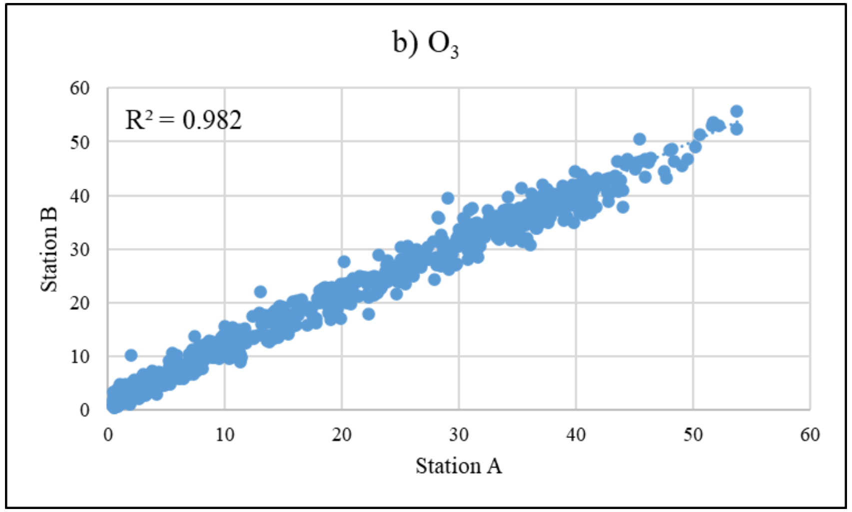
- For the El Paso District, winter season emissions rates for urban arterial roads at an average speed of 2.5 mph were obtained from Texas A&M Transportation Institute (TTI) and converted into the appropriate units for use in the AERMOD model.
- Historical average wait times for February and March at the BOTA were obtained from the CBP database and used to normalize the winter emissions rates, creating hourly emissions rates for an average weekday and weekend

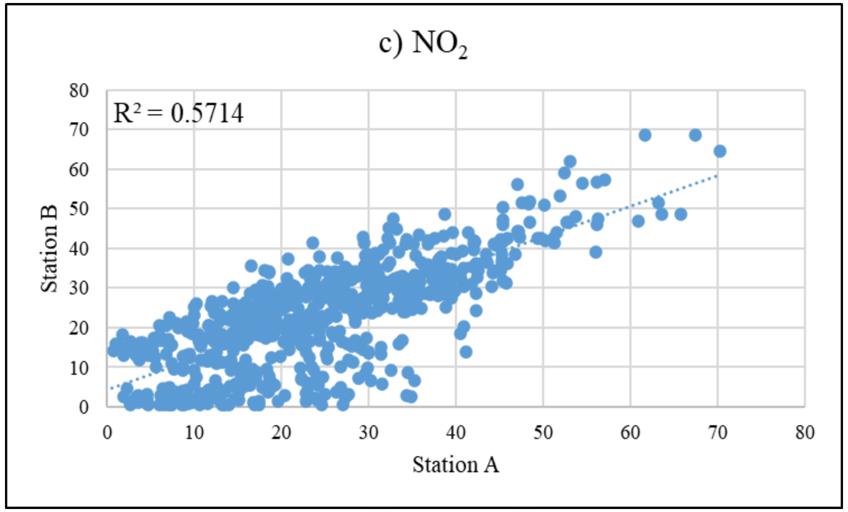
Unit	PM_{25}	PM_{10}	NO_2
g/mile	0.058	0.373	0.033
g/veh-hr	0.145	0.933	0.083
g/veh-s	4.03E-05	2.59E-04	2.31E-05
g/s-m2	1.92E-06	1.23E-05	1.10E-06



Results and Discussion: Concentrations at BOTA





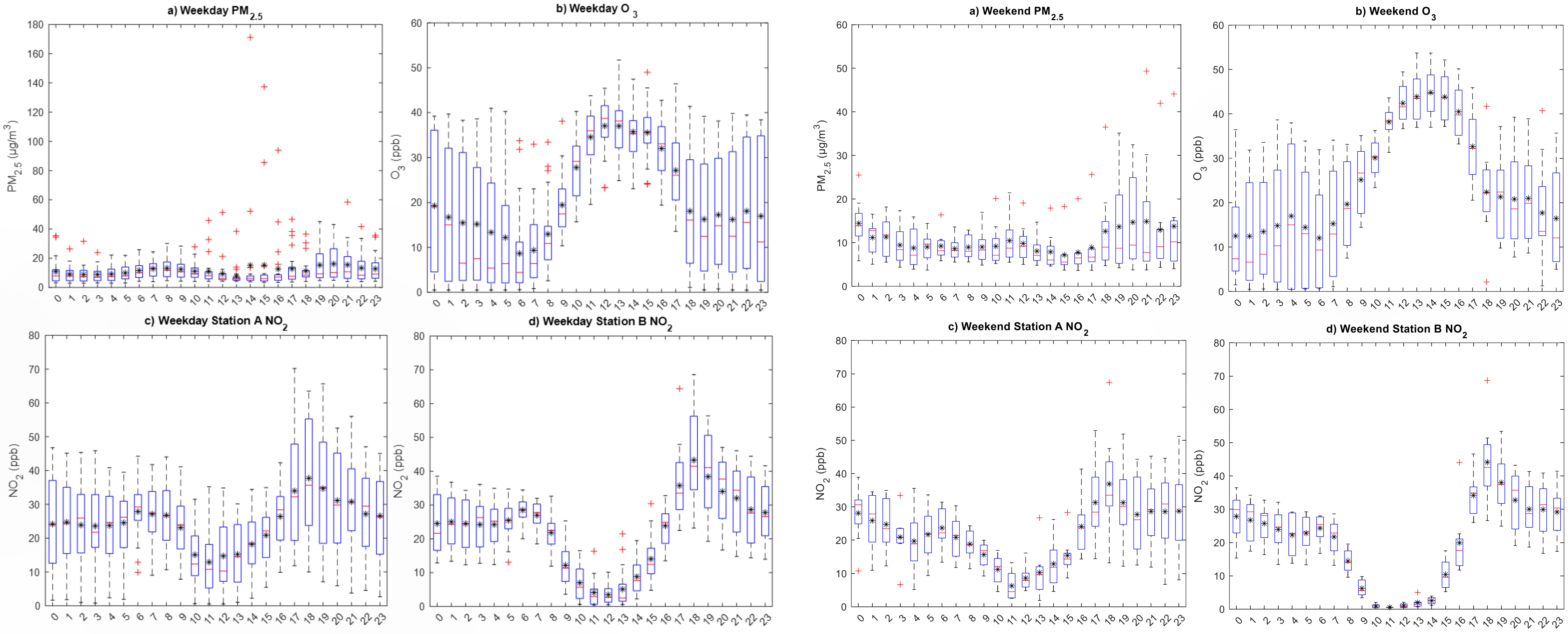


$PM_{2.5}$ **O_3** **NO_2**

5-Minute Data								
Pollutant		Average	Median	Standard Deviation	Minimum	25th Percentile	75th Percentile	Absolute Maximum
$PM_{2.5}$ ($\mu g/m^3$)	A	11.6	7.9	13.6	2.7	5.5	12.8	434.4
	B	11.6	8.0	13.4	2.6	5.6	12.9	454.0
O_3 (ppb)	A	23.7	25.9	14.2	0.0	10.2	35.7	97.0
	B	23.7	25.6	14.5	0.1	9.9	36.2	110.4
NO_2 (ppb)	A	24.9	23.9	13.5	0.0	14.9	33.9	107.0
	B	24.9	25.0	12.7	0.0	16.2	32.3	118.9

1-Hour Data								
Pollutant		Average	Median	Standard Deviation	Minimum	25th Percentile	75th Percentile	Absolute Maximum
$PM_{2.5}$ ($\mu g/m^3$)	A	11.6	8.1	11.8	2.9	5.7	13.1	171.2
	B	11.6	8.3	11.7	2.8	5.7	12.9	167.5
O_3 (ppb)	A	22.2	24.0	14.5	0.4	7.5	35.1	53.7
	B	23.3	24.8	14.2	0.5	9.5	35.8	55.7
NO_2 (ppb)	A	24.0	23.3	12.9	0.5	14.5	32.4	70.2
	B	23.1	23.7	12.9	0.5	14.2	31.5	68.7

Diurnal Patterns of Pollution at BOTA



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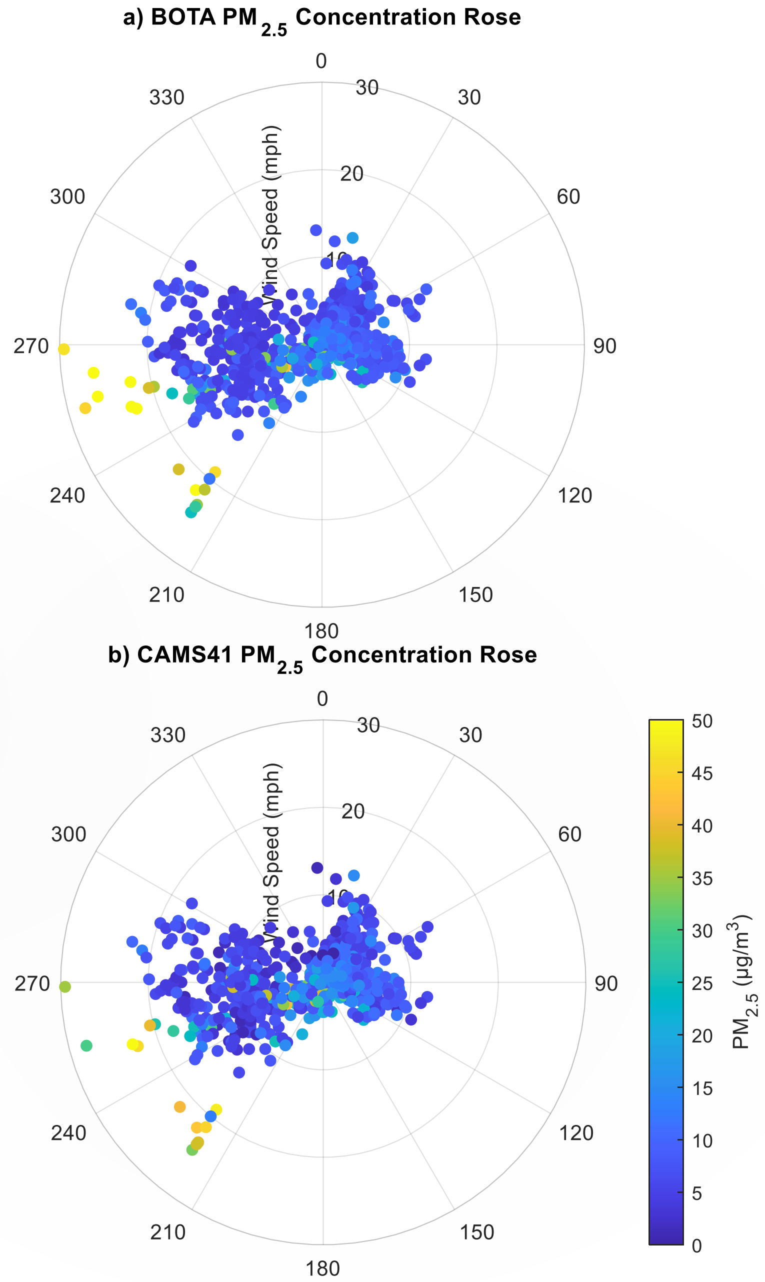
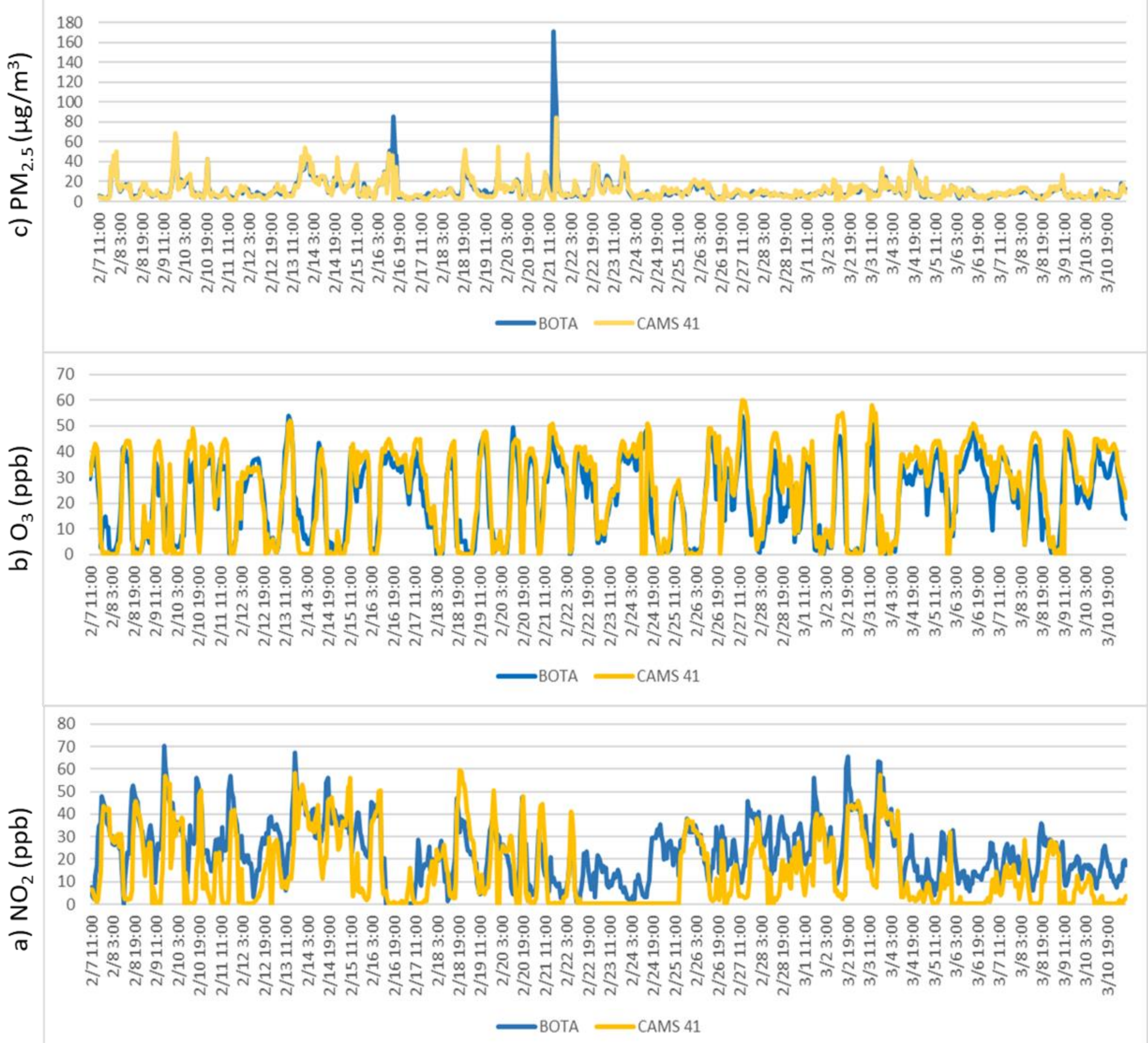
Comparison of BOTA to CAMS 41





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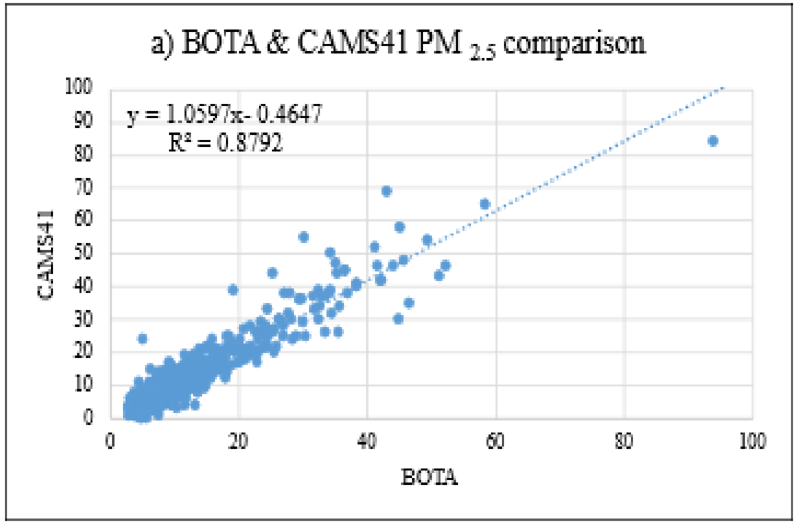
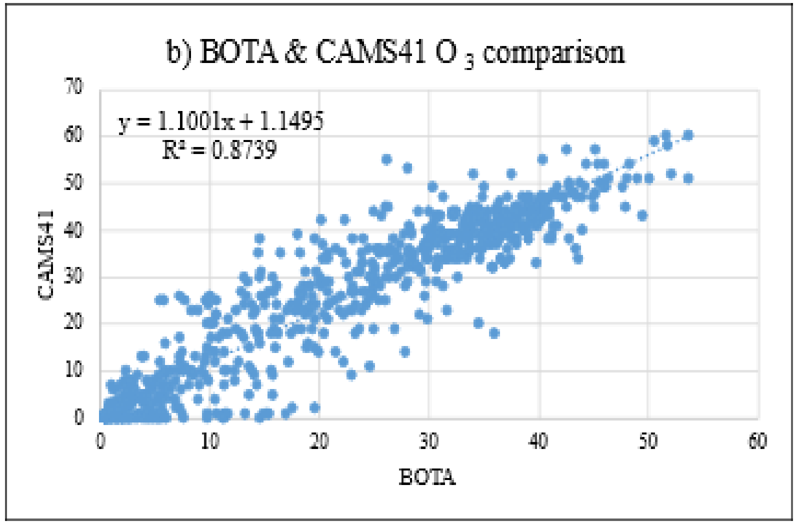
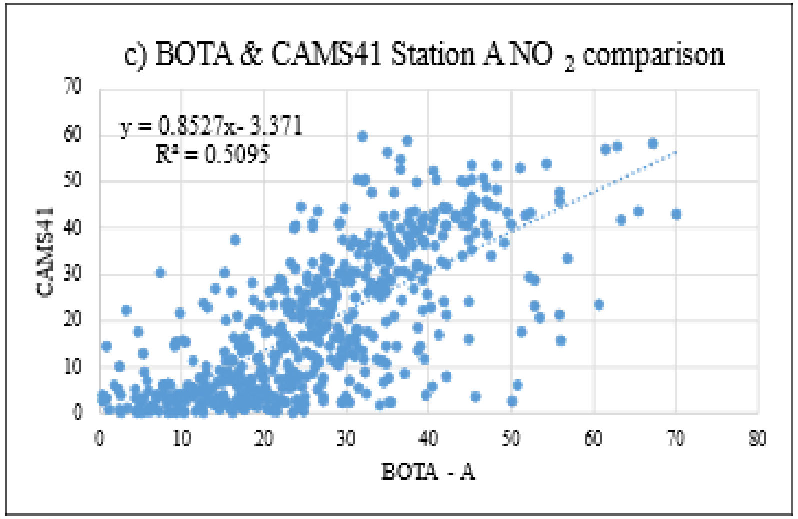
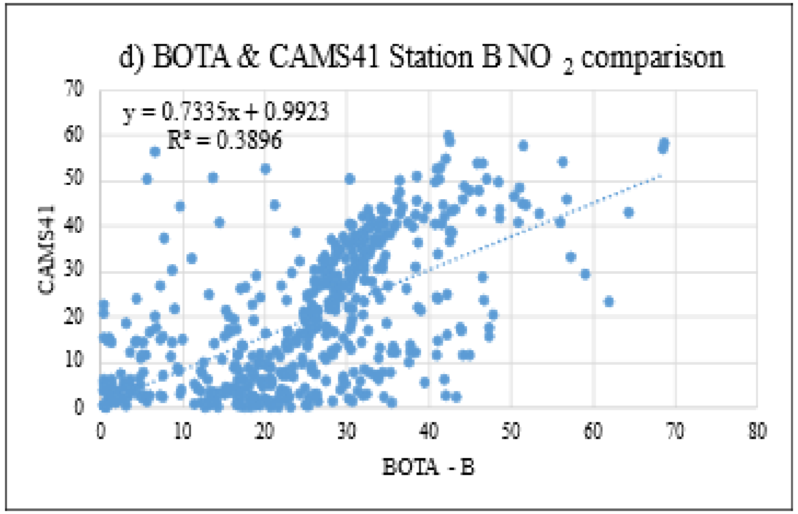
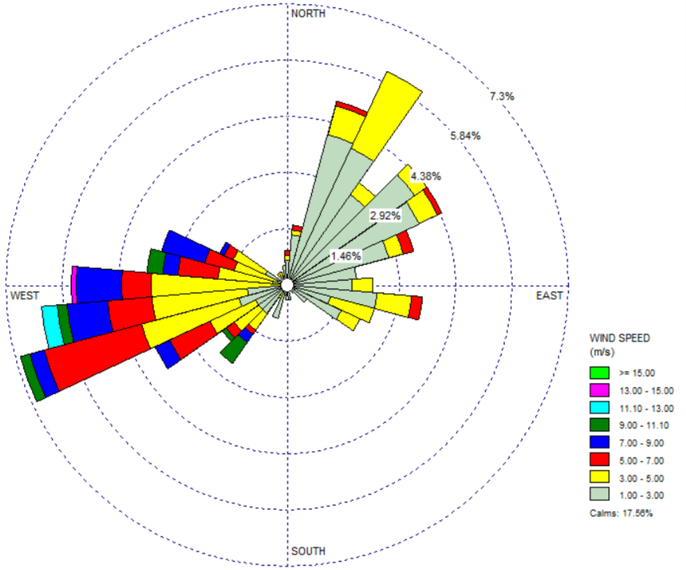


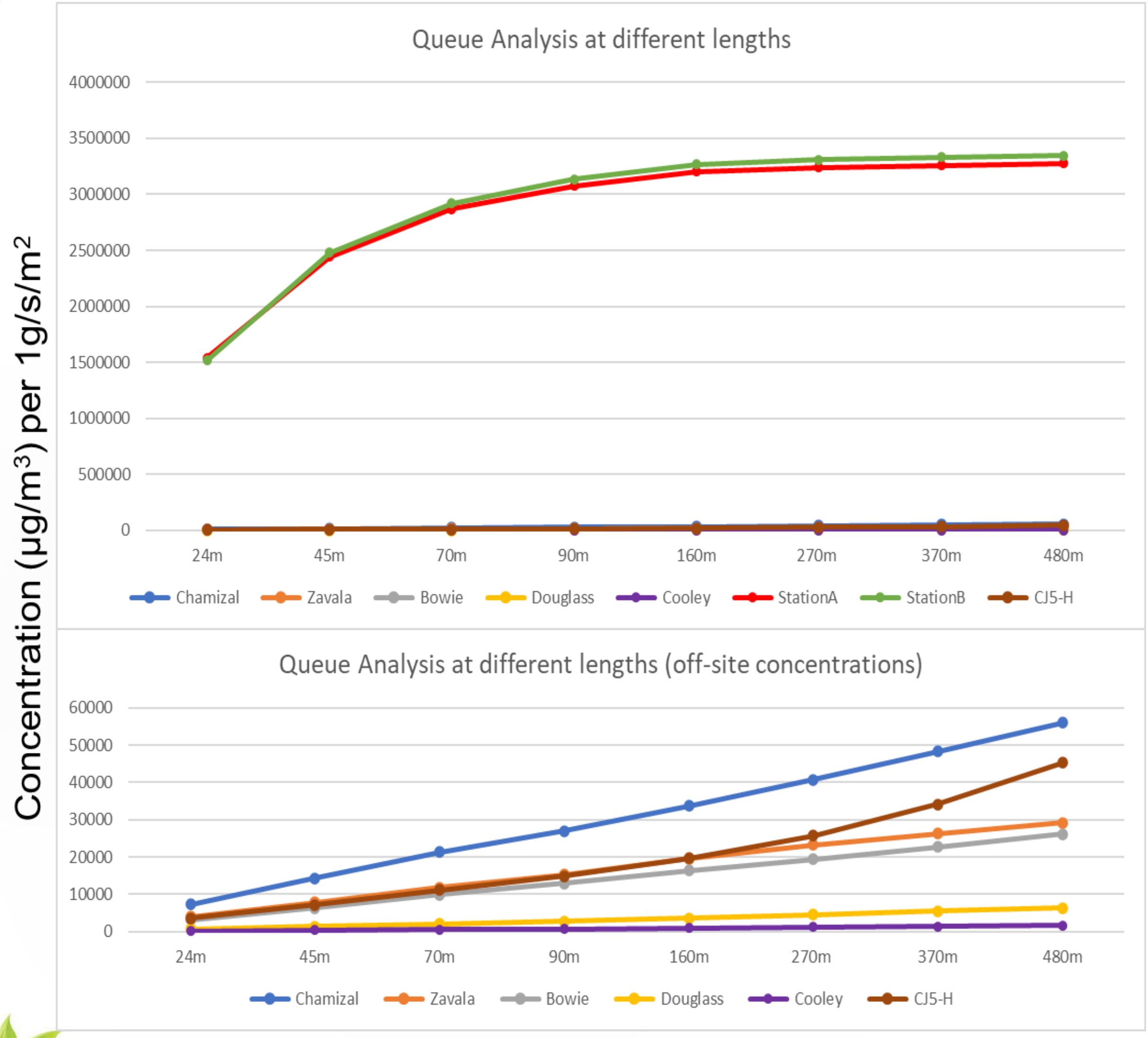








Concentration Estimates Predicted by AERMOD



- Impact of vehicle queue length on on-site and off-site air pollutant concentrations at the BOTA
- On-site concentrations stabilize with increasing queue length, while off-site concentrations are more sensitive to the size of the source.
  - Even with longer queues beyond 100 m, in-traffic concentrations at the POE would stabilize at a maximum level

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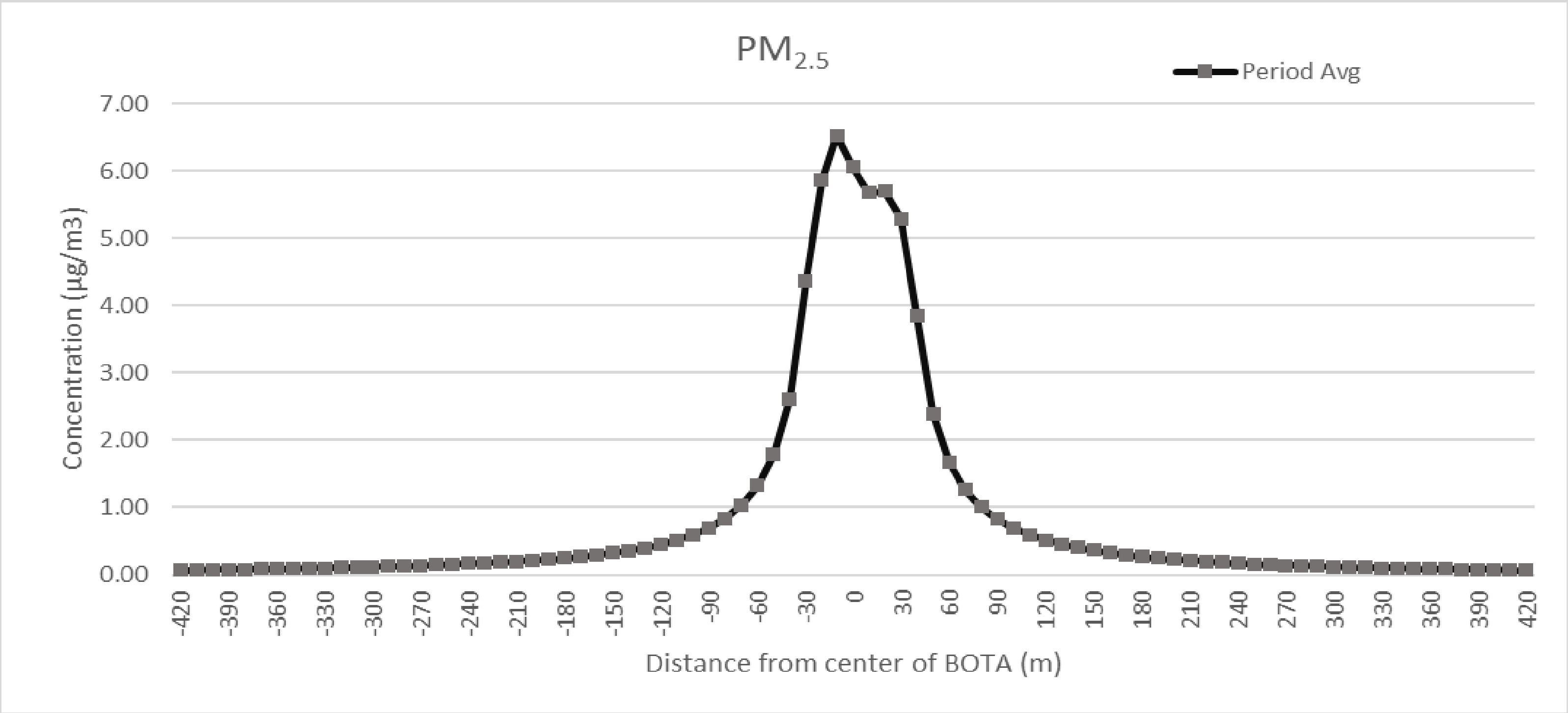
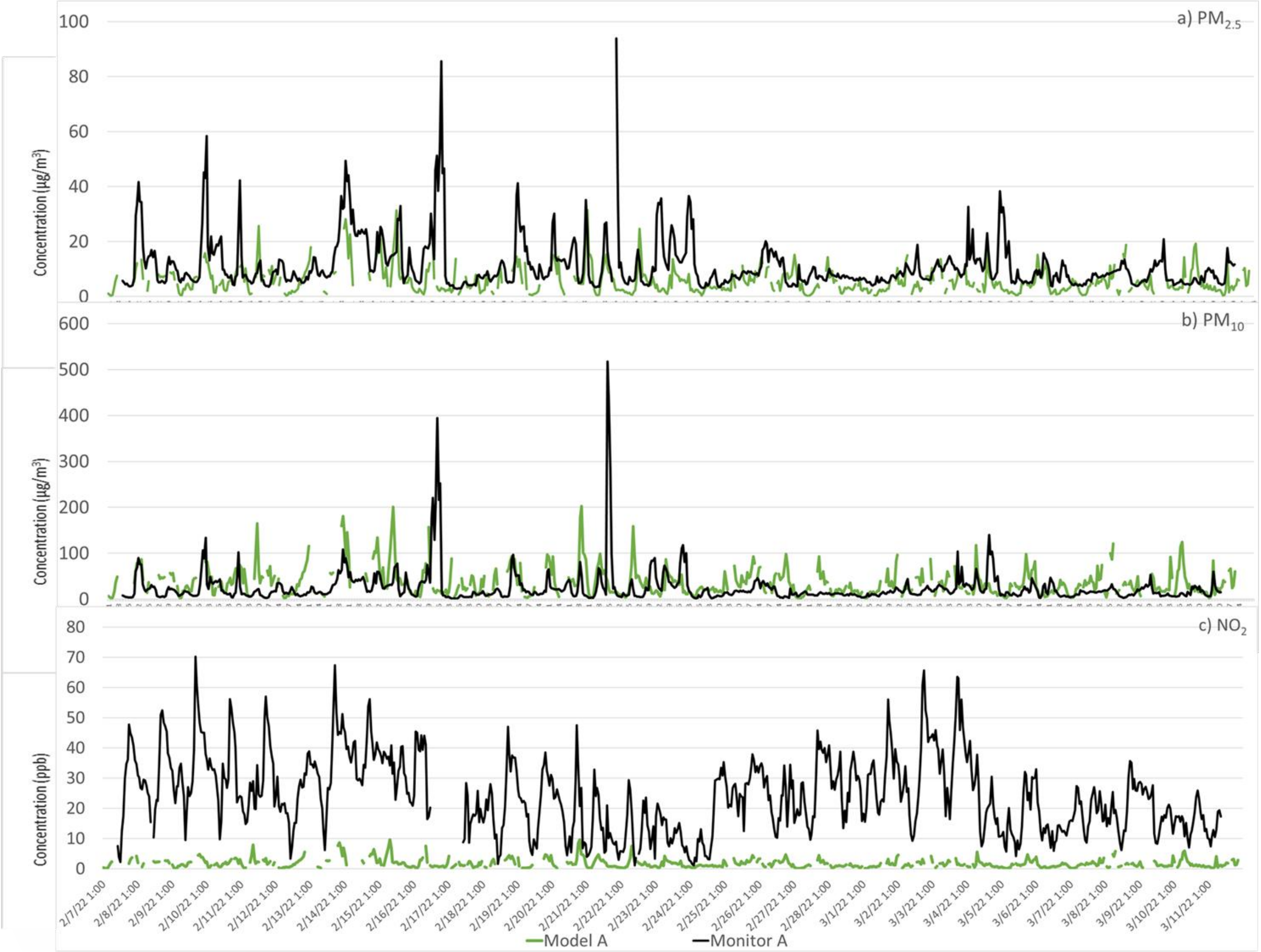
Cross-Roadway Concentration Distribution

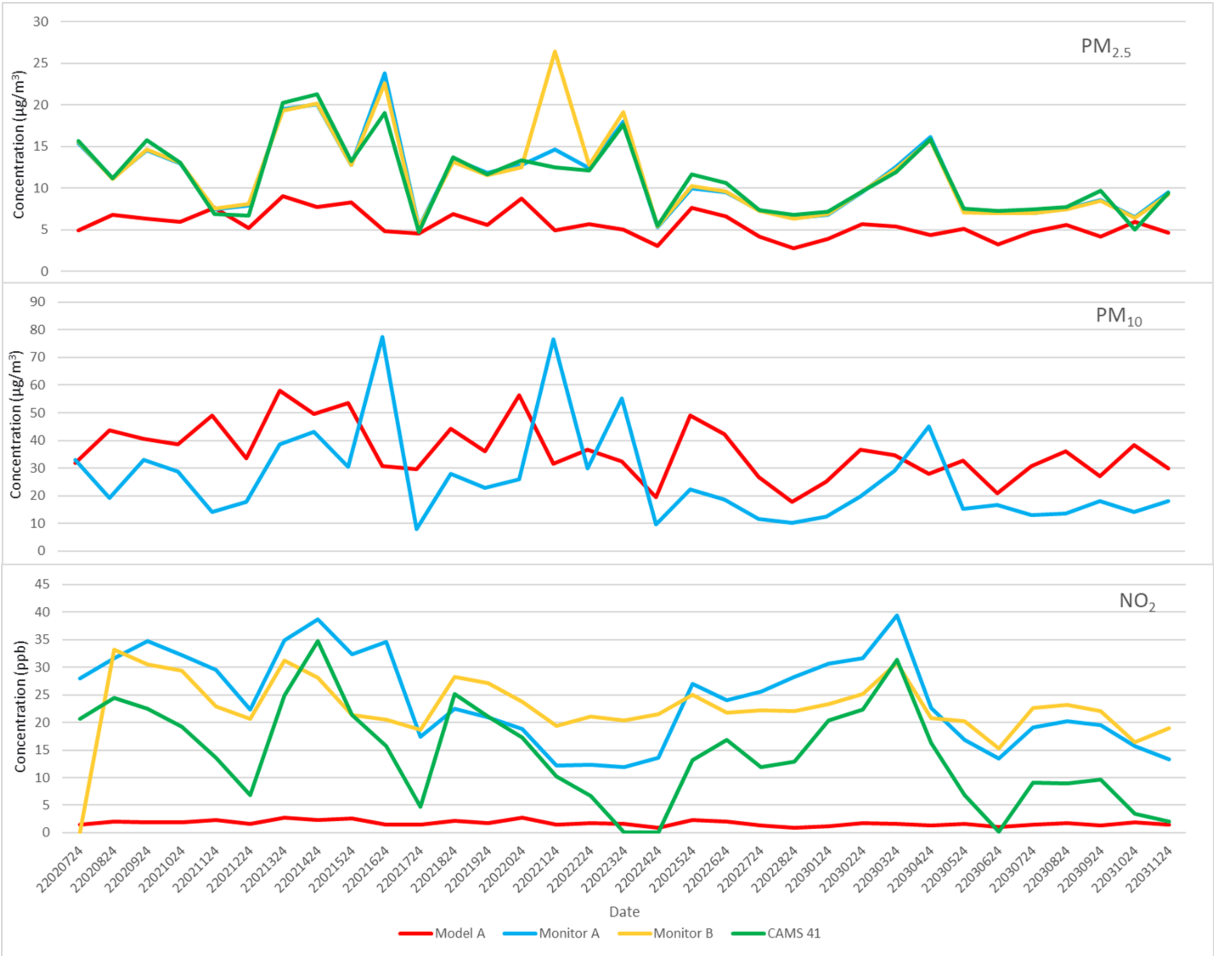


- Receptors placed at increasing distances from the roadway
  - most of the dispersion occurring within 200 m of the highway.
- The dispersion pattern of $PM_{2.5}$ away from the roadway suggests a tenfold decrease in concentrations within 100 m from the center of the BOTA

Comparison of Modeled and Monitored Concentrations



1 hr Avg



24hr Avg

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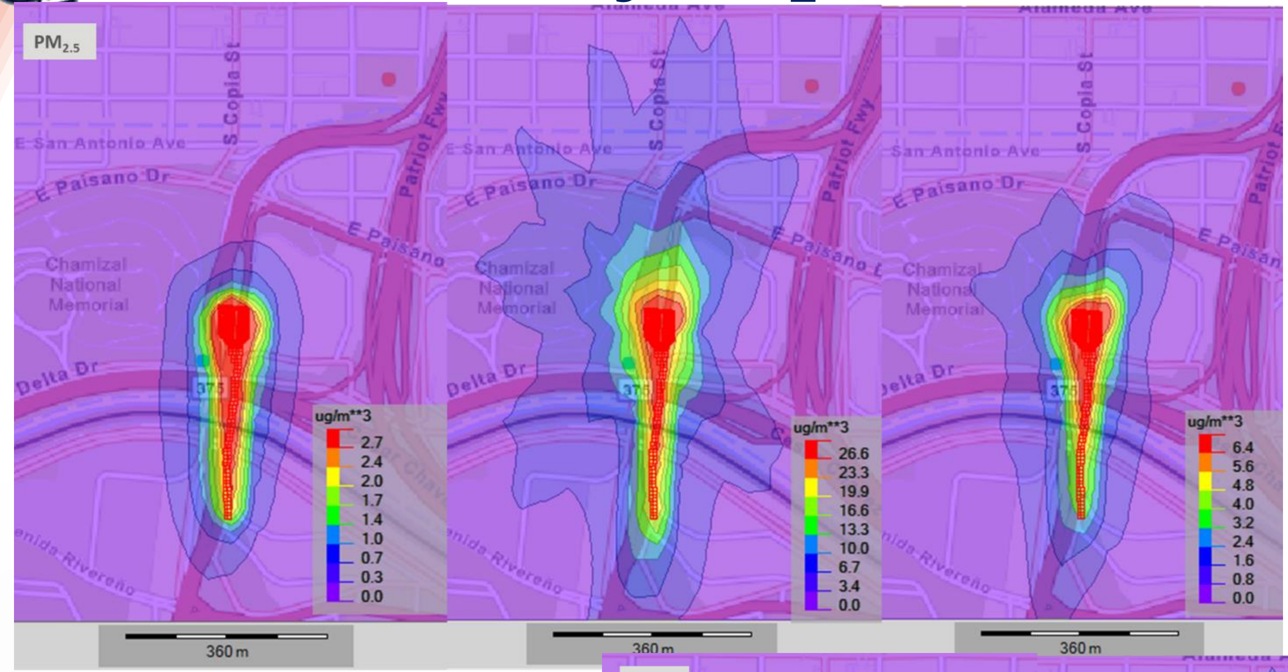
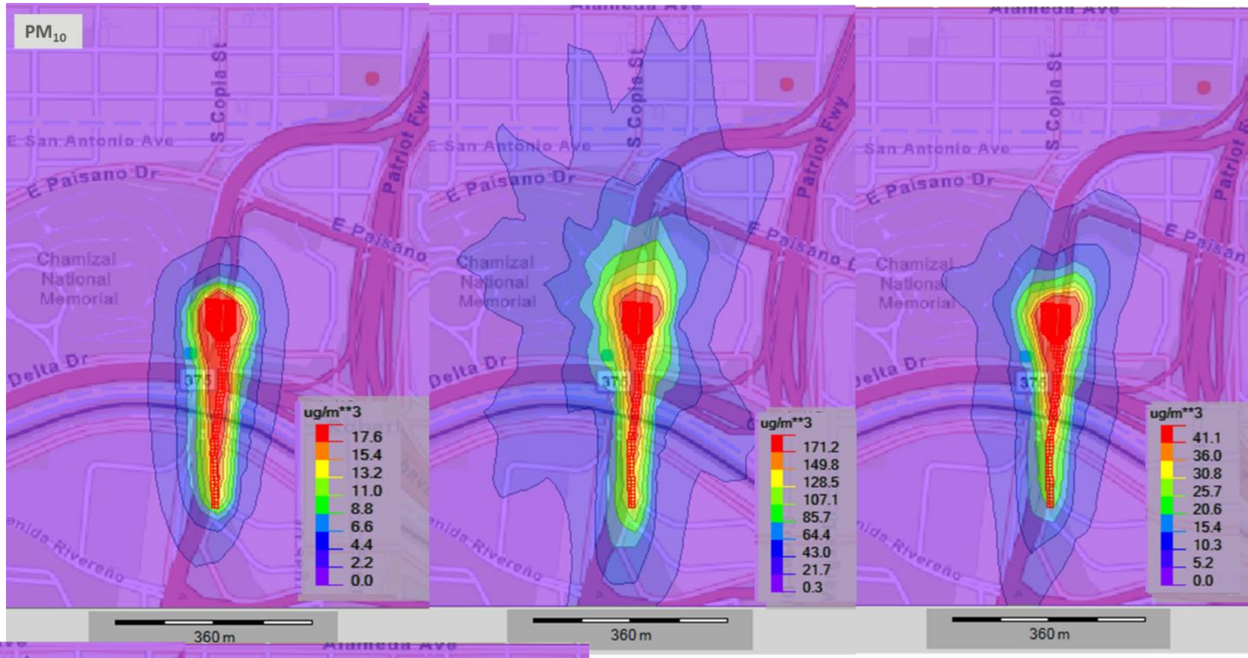
Community Exposure Resulting from BOTA Emission

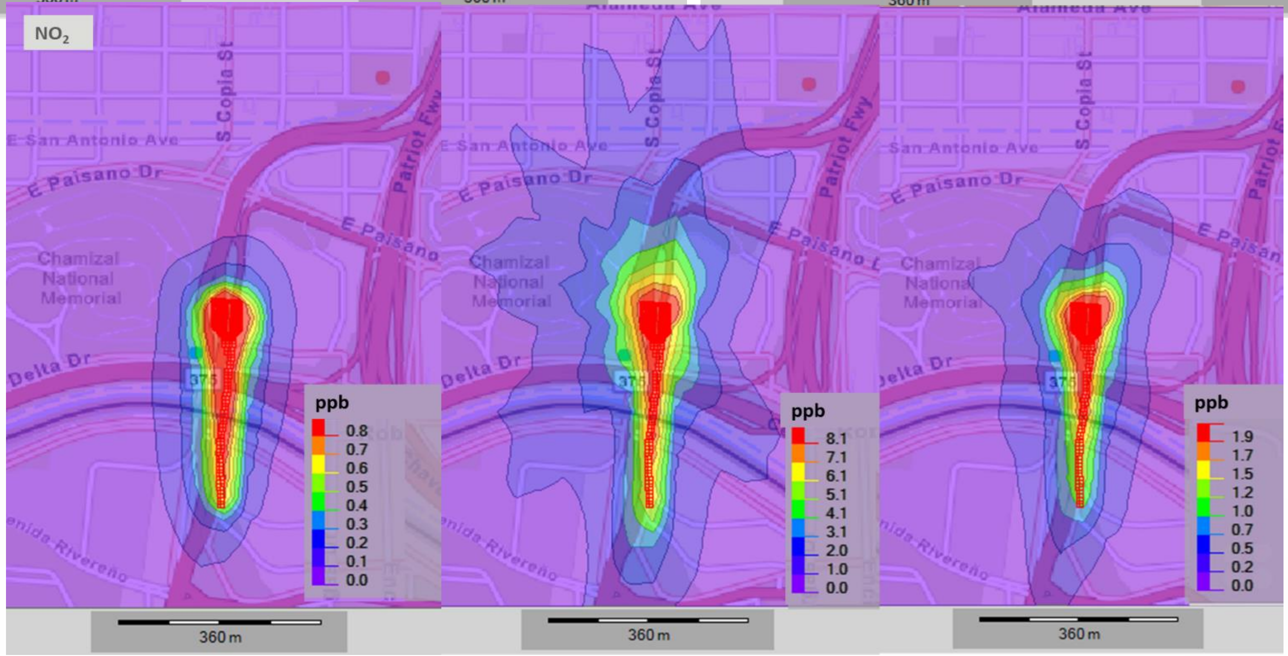
	Modeled			Monitored			Ratio (Model/Monitor)			Average Percentage Difference between BOTA and CAMS 41		
Period Average	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	NO_2 (ppb)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	NO_2 (ppb)	$PM_{2.5}$ (%)	PM_{10} (%)	NO_2 (%)	$PM_{2.5}$ (%)	PM_{10} (%)	NO_2 (%)
StationA	5.73	36.90	1.75	11.20	25.13	24.23	51	147	7.2	0.3%		52%
StationB	5.86	37.73	1.79	11.55	27.64	23.25	51	136	7.7	3.4%		48%
CAMS41	0.08	0.49	0.02	11.17	—	14.29	0.7	—	0.2			
Bowie	0.03	0.21	0.01	4.72	—	—	0.7	—	—			
Zavala	0.05	0.32	0.02	3.92	—	—	1	—	—			
CJ5-H	0.08	0.51	0.02	3.81	—	—	2	—	—			
Douglass	0.01	0.05	0.00	4.12	—	—	0.2	—	—			
Cooley	0.00	0.01	0.00	3.68	—	—	0.1	—	—			
TollBooth	3.80	24.44	1.16	—	—	—	—	—	—			
Office	1.81	11.69	0.55	—	—	—	—	—	—			
EastPedestrian	4.28	27.59	1.31	—	—	—	—	—	—			
SBToll	1.72	11.07	0.52	—	—	—	—	—	—			
WestPedestrian	1.26	8.13	0.39	—	—	—	—	—	—			

Community Exposure Resulting from BOTA Emission



Period Average





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Summary

- A 1-month air monitoring campaign at the BOTA in El Paso, Texas, using FEM instruments assessed exposure levels to facility operators and users.
- Concurrent PM monitoring in the nearby community was performed using low-cost sensors.
- Air dispersion modeling predicted $PM_{2.5}$, PM_{10}, and NO_2 levels at the BOTA and surrounding areas, comparing modeled and monitored concentrations.
- Modeled pollution levels stabilize at a queue length of approximately 270 m, with rapid dispersion as distance from the BOTA increases.

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Future Research

- Expand modeling and dispersion parameters used in AERMOD, considering emissions rates for idling vehicles or different road types.
- Focus on expanding community monitoring and establishing background concentrations. Investigate cross-border air quality issues at more POEs to validate findings.
- Consider factors influencing environmental justice for border crossers and neighboring populations.

Comments and Questions

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