Monitoring of three criteria air pollutants at an international port of entry

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2022 National Ambient Air Monitoring Conference

August 22-25, Pittsburgh, PA

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Acknowledgements

This project was supported by a grant from the U.S. Department of Transportation through the Center for Advancing Research in Transportation Emissions, Energy, and Health (CARTEEH). We thank the U.S. Customs and Border Protection for their assistance. We also thank Mr. Sergio Vasquez, and Eddie Moderow of TCEQ and Mr. Alan Wiernicki, Mr. Ernesto Ortiz, Mr. Abel Carreon, and Mr. Joe Parga of EPISD for their assistance in setting up the low-cost sensors on EPISD campuses.

The contents of this paper are solely the responsibility of the authors and do not necessarily represent the official views of the U.S. DOT, TCEQ, or U.S. CBP.

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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 the users of the facilities as well as residents of nearby communities
- 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 time at the POE potentially increases users' exposure
- The Bridge of the Americas (BOTA) has the highest volume of traffic in El Paso, Texas with 3.3 million northbound vehicles crossed from Cd. Juarez to El Paso and over 600,000 pedestrians crossing on foot in 2021
- Few air quality studies have been conducted at the POEs due to concerns of security compromise, traffic interruption, and vandalism

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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 two objectives:

- Establish the baseline exposure concentrations for POE workers and users; and
- Evaluate the pollution impacts of POE emissions on the nearby community using concurrent monitoring and by collecting and analyzing pollutant data at the traffic lanes on the BOTA

To the best of our knowledge, no similar studies have been conducted to monitor in-traffic air pollution at a POE. Our results do not apply to in-vehicle exposure.

Study Design

- Study Period: Feb. 7 – March 12, 2022
- Two sets of instruments for continuous $PM_{2.5}$, O_3, and NO_2 monitoring at the Bridge of the Americas (BOTA)
- Continuous $PM_{2.5}$ monitoring at 5 community locations within 3 miles from the BOTA
- A State-operated FRM monitoring site within 0.4 miles from BOTA

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Data Collection

- $PM_{2.5}$
  - GRIMM 11A Portable Laser Aerosol Spectrometer and Dust Monitor
  - PurpleAir PA-II

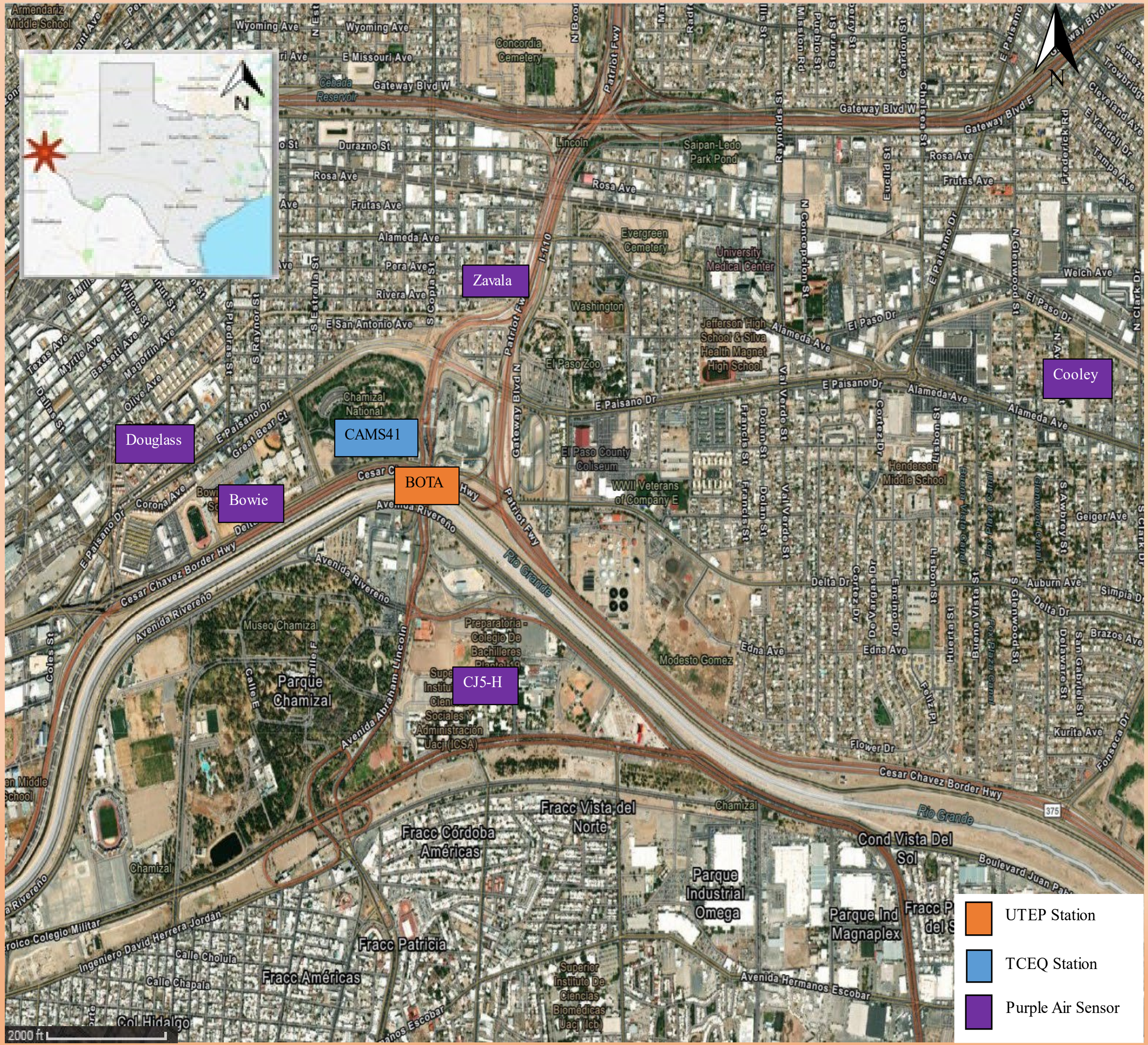
- O3

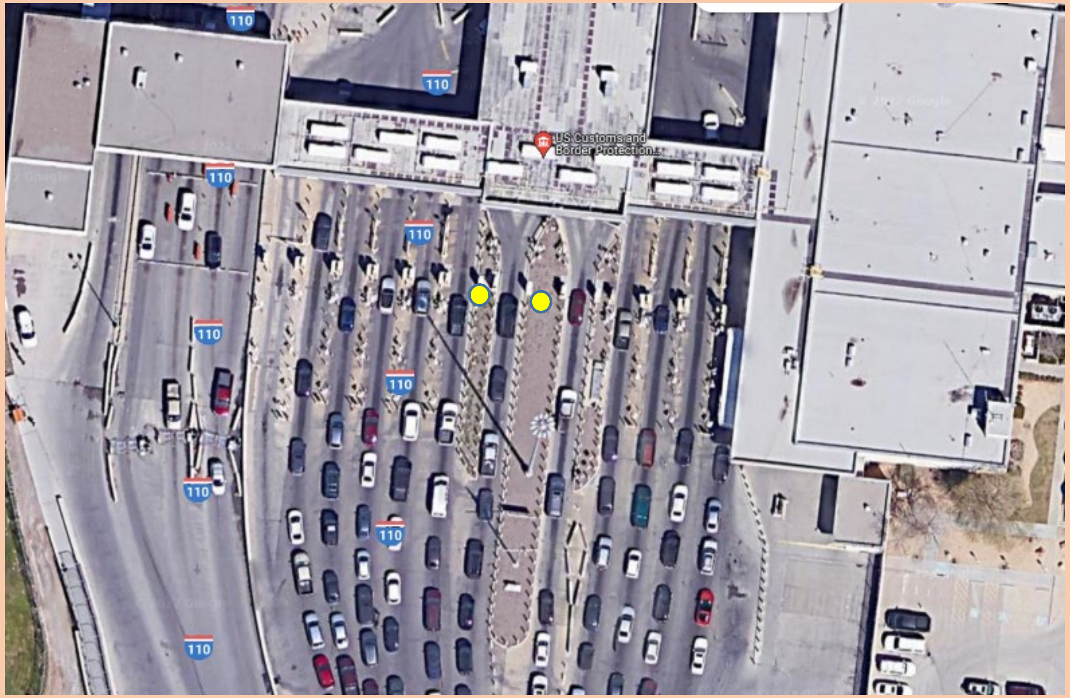
2B Technologies Model 202
Ozone Monitor

- NO_2

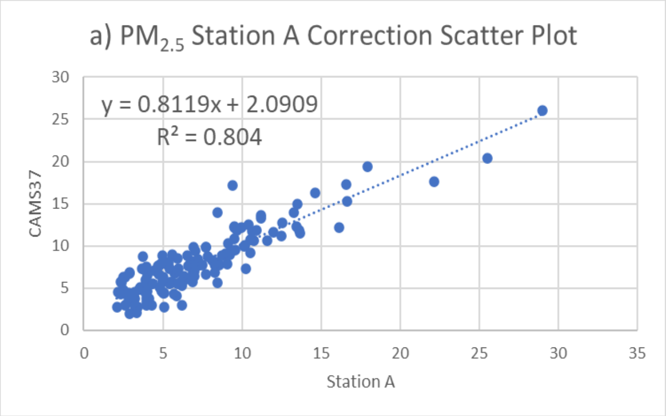
  2B Technologies Model 405
  for NO_2/NO/No_x Monitor

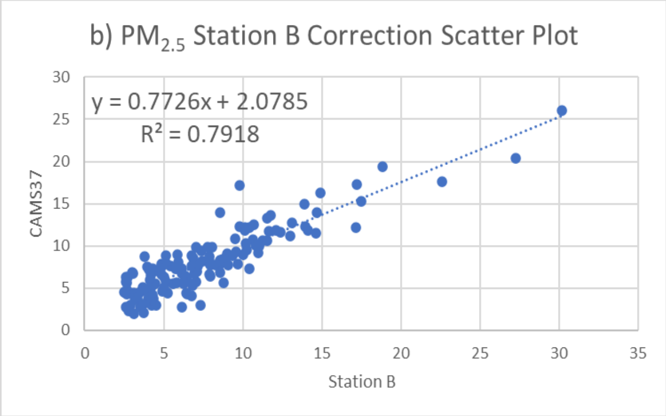
Sampling Locations and Instrumentation Setup

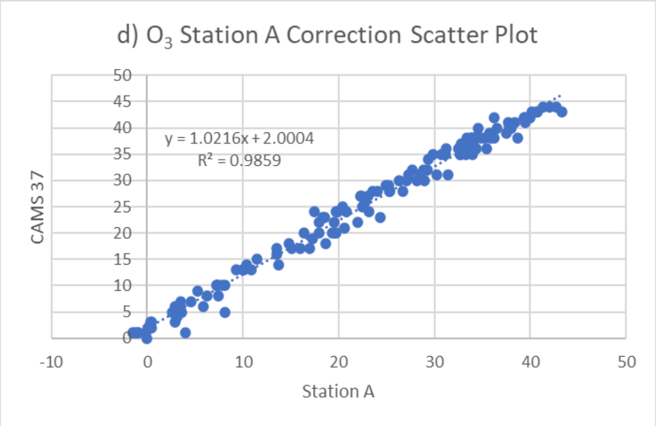


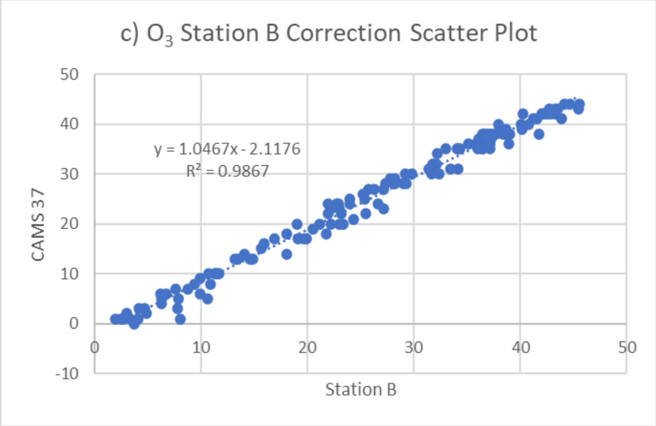


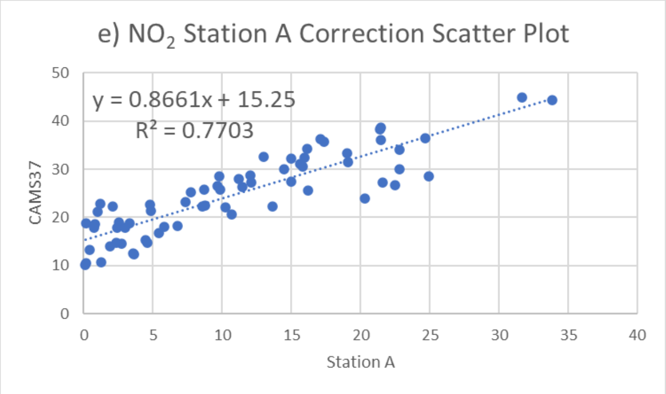
Correlations between FEM and FRM Instruments

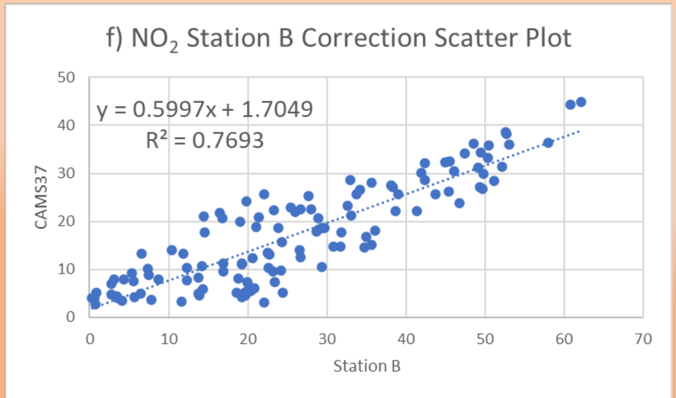












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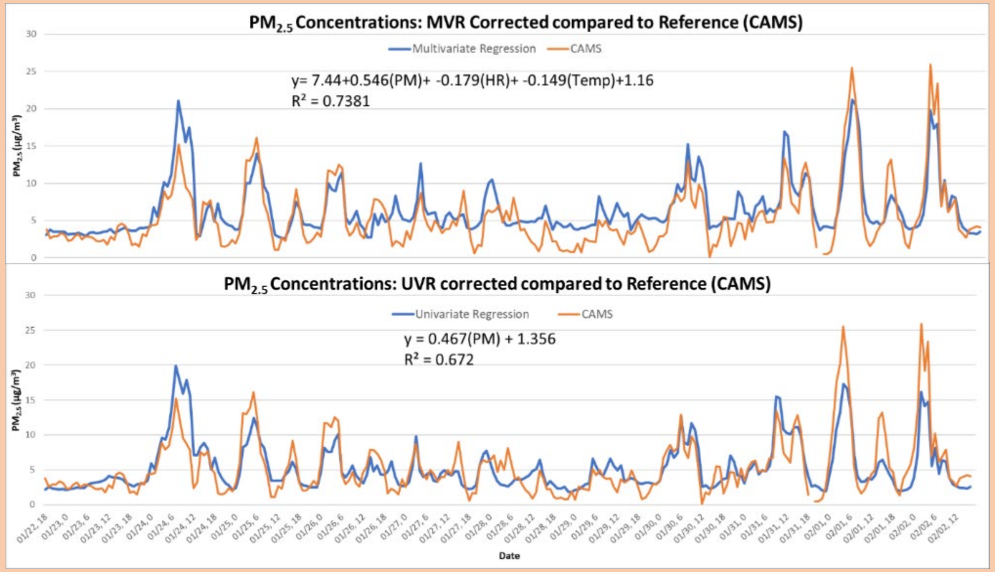
Correlations between Low-cost $PM_{2.5}$ Sensors and FRM Instrument

Multivariate $C_{FRM} = \beta0+\beta1(C_{obs})+\beta2(HR)+\beta3(Temp)+\mathcal{E}$

Univariate $C_{FRM} = A \bullet C_{obs} + B$

Sensor	Multivariate Linear Regression					Univariate Linear Regression			Sensor Performance	
	β0	β1	β2	β3	R^2	A	B	R^2	Interchannel Performance (R^2)	Interdevice Performance (R^2)
Cooley	7.45	0.54	-0.18	-0.15	0.85	0.47	1.33	0.67	0.98	NA
Douglass 1	6.74	0.57	-0.18	-0.13	0.84	0.47	1.34	0.66	0.98	0.51
Douglass 2	7.39	0.64	-0.18	-0.11	0.86	0.51	1.52	0.66	0.99	
Zavala 1	6.63	0.64	-0.16	-0.1	0.84	0.56	1.69	0.67	0.96	0.99
Zavala 2	5.1	0.64	-0.1	-0.07	0.86	0.58	1.66	0.66	0.82	
Bowie	5.93	0.52	-0.19	-0.02	0.62	0.62	1.65	0.23	0.99	NA
CJ5-H 1	8.44	0.69	-0.20	-0.16	0.86	0.49	1.45	0.68	0.98	0.99
CJ5-H 2	5.49	0.58	-0.15	-0.06	0.85	0.54	2.82	0.22	0.95	



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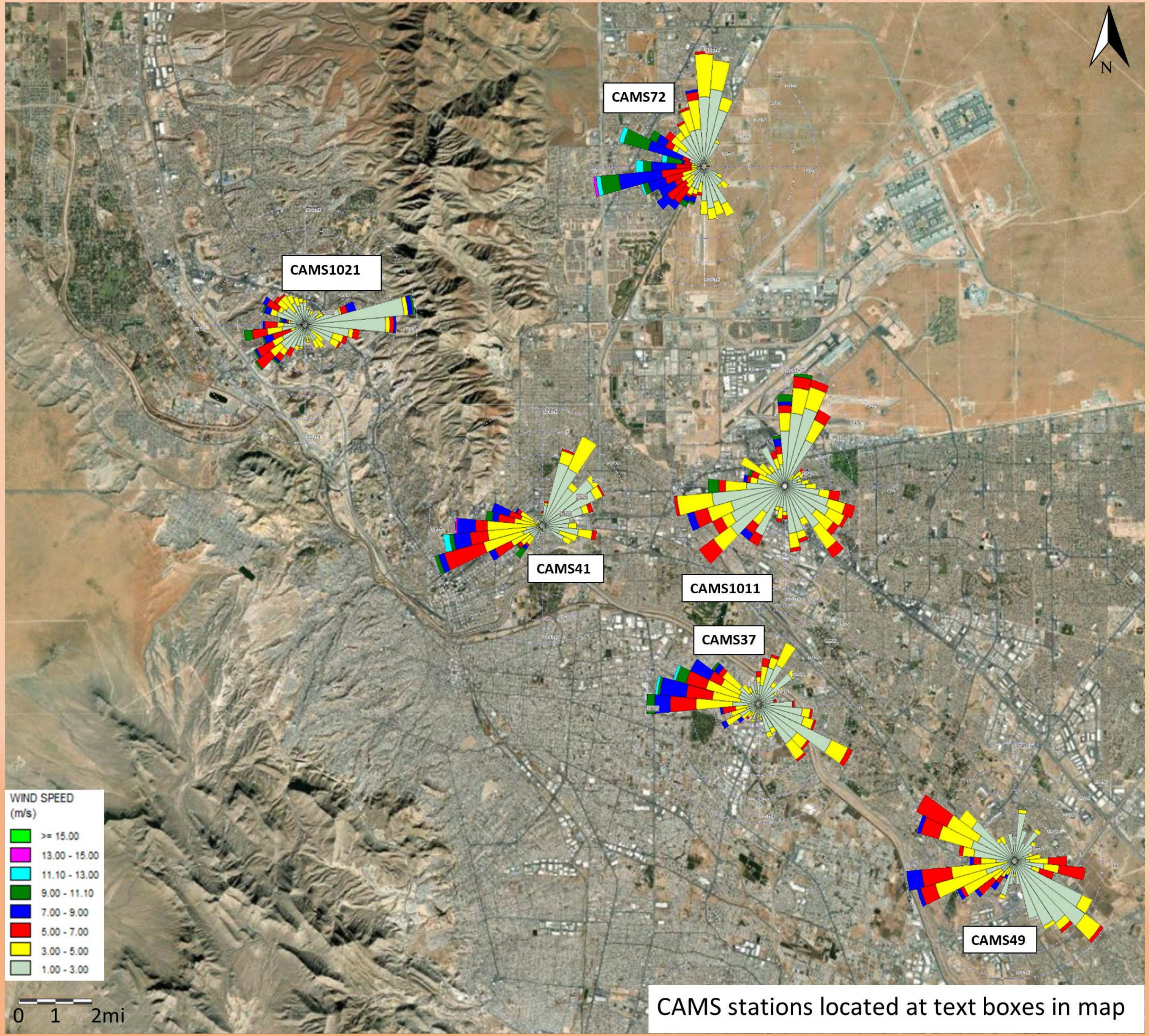
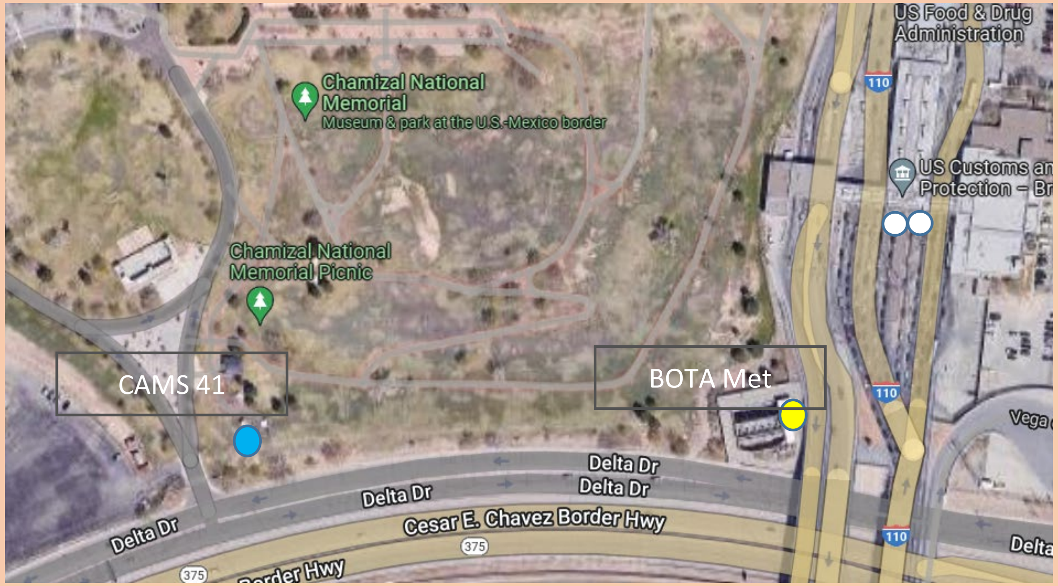
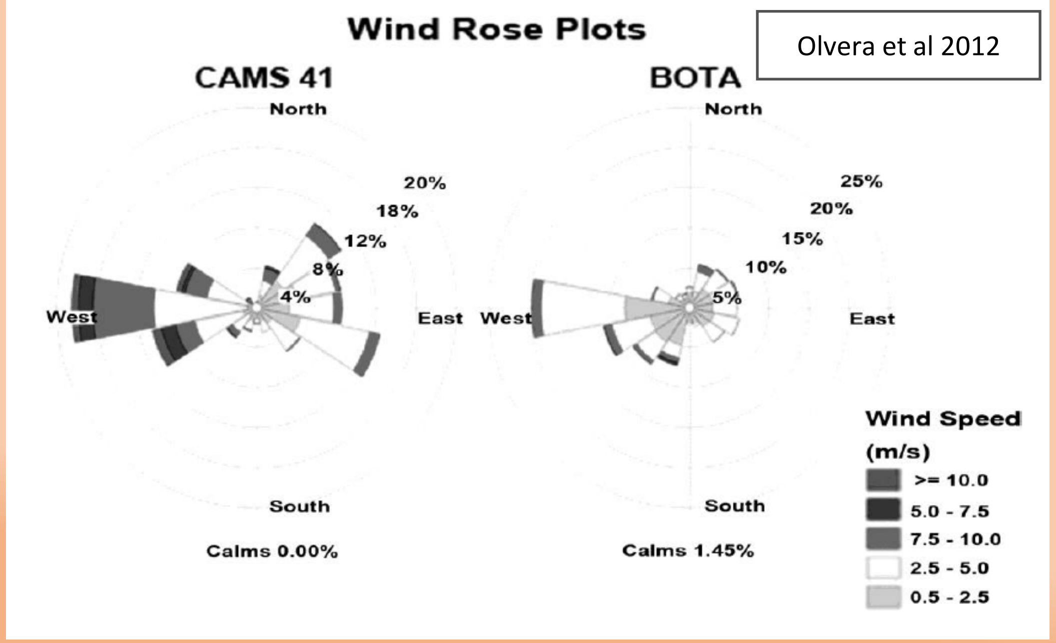
Local Meteorology



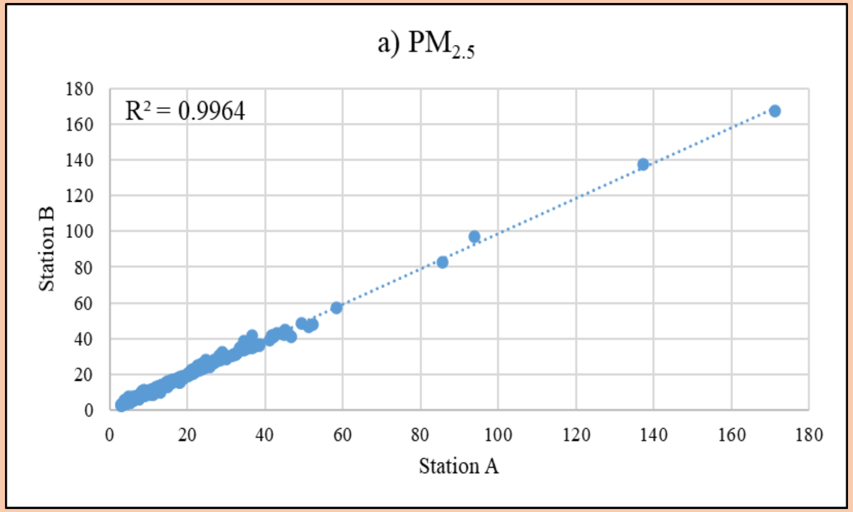
CAMS stations located at text boxes in map



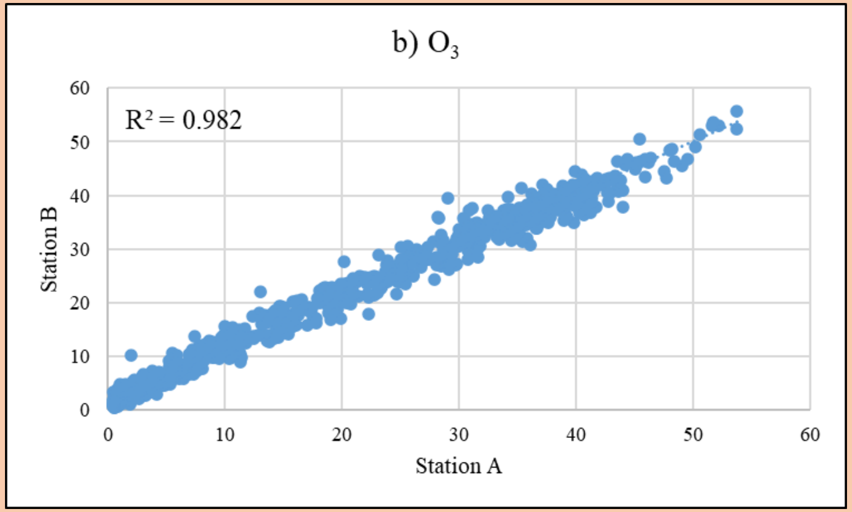


Results and Discussion

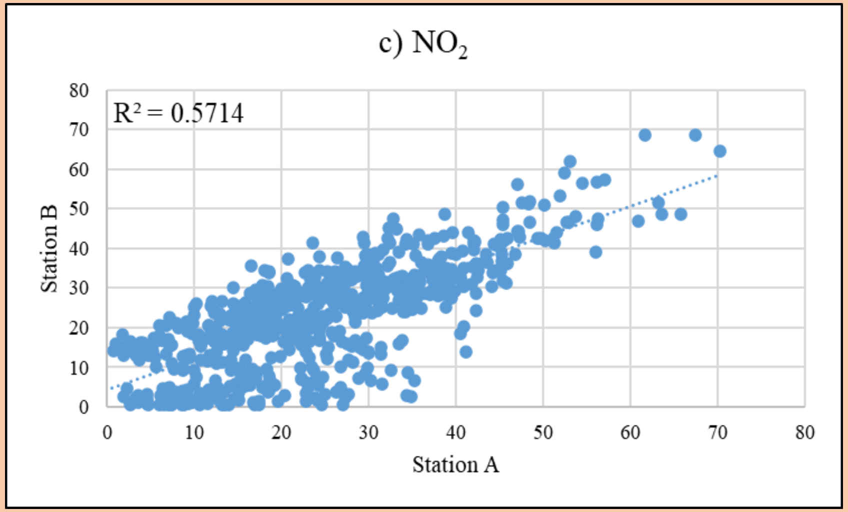
Concentrations at BOTA



$PM_{2.5}$



O_3

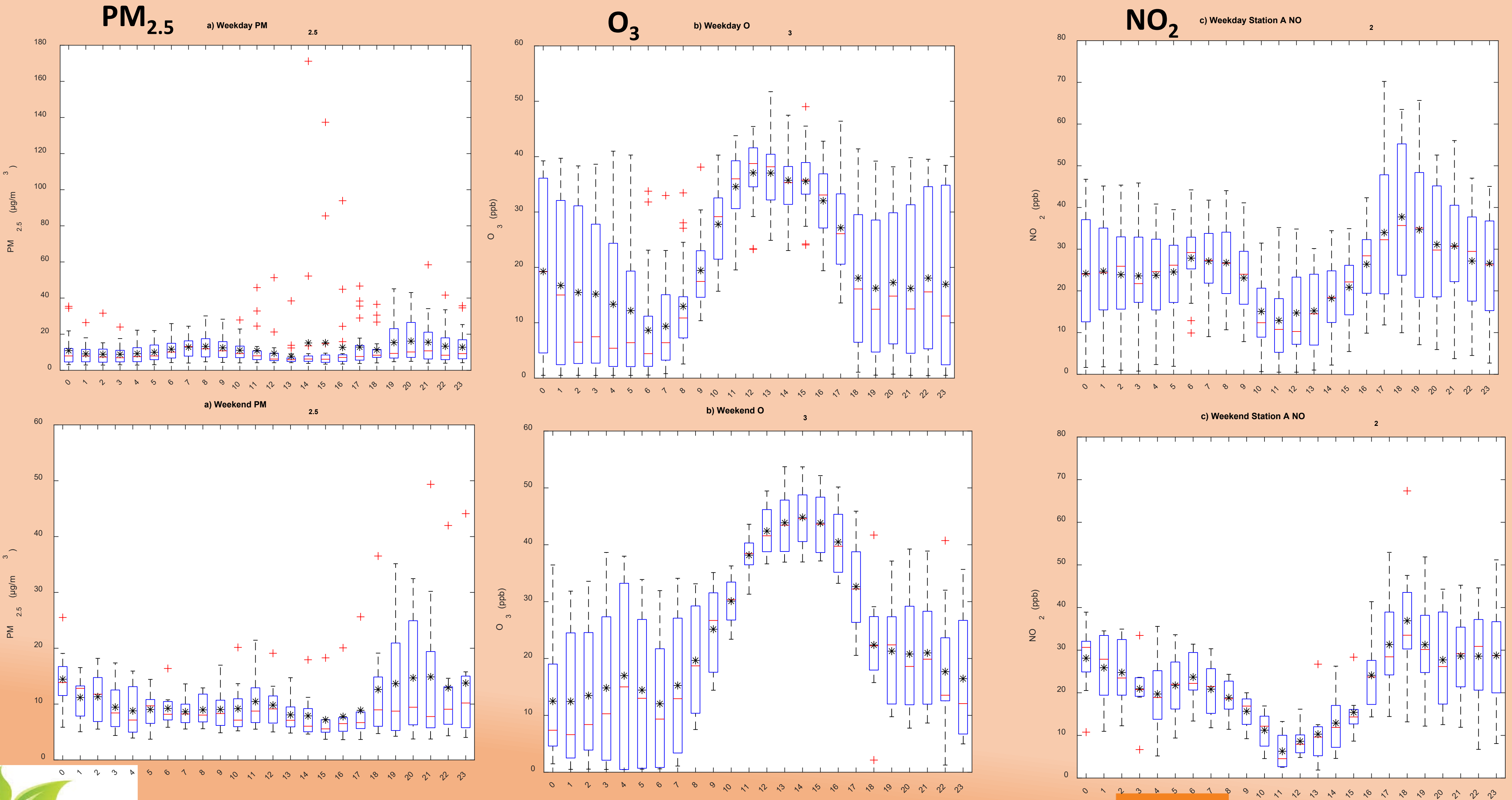


NO_2

5-Minute Data								
Pollutant		Average	Median	Standard Deviation	Minimum	25th Percentile	75th Percentile	Absolute Maximum
$PM_{2.5}$ (µg/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
$PM_{2.5}$ (µg/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



Comparison of BOTA to NAAQS

Pollutant	BOTA Concentrations		Reference Standard	
	Observed	Description	NCAAQ	Description
$PM_{2.5}$	**11.6 μg/m³** **26 μg/m³**	All-period Average Max. 24-hr	12 μg/m³ 35 μg/m³	Annual Average Max 24-hr Average
O_3	**56 ppb**	Max. 1-hr	70	Max 8-hr Average
NO_2	**70 ppb** **24 ppb**	Max 1-hr Average All-period Average	100 ppb 53 ppb	Max 1-hr Average Annual Average

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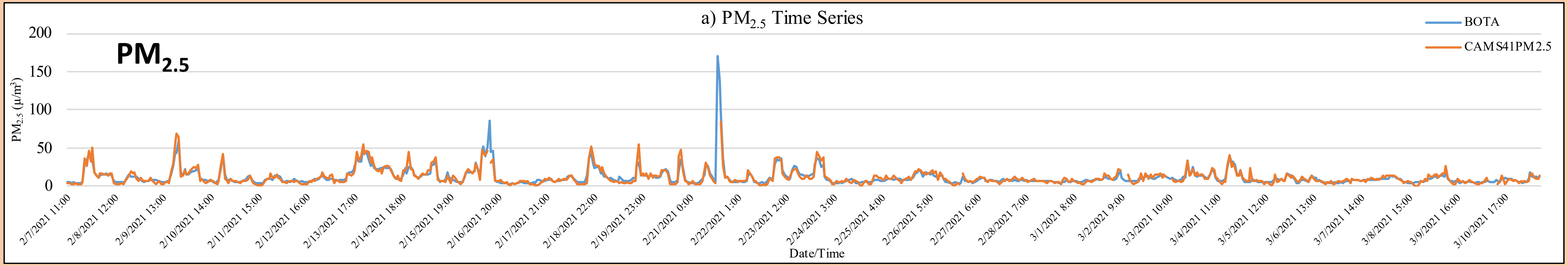
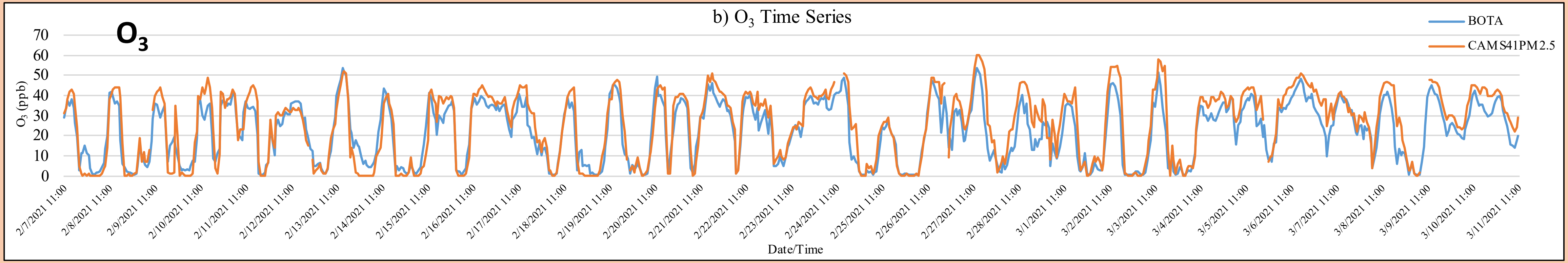
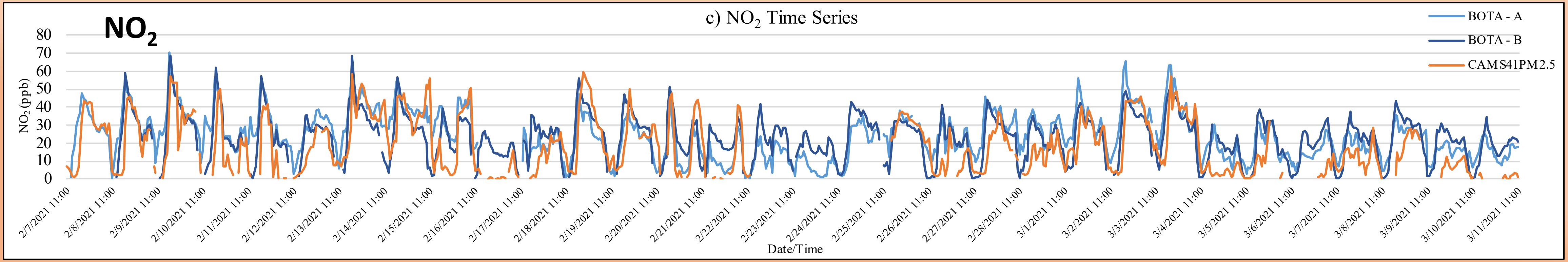
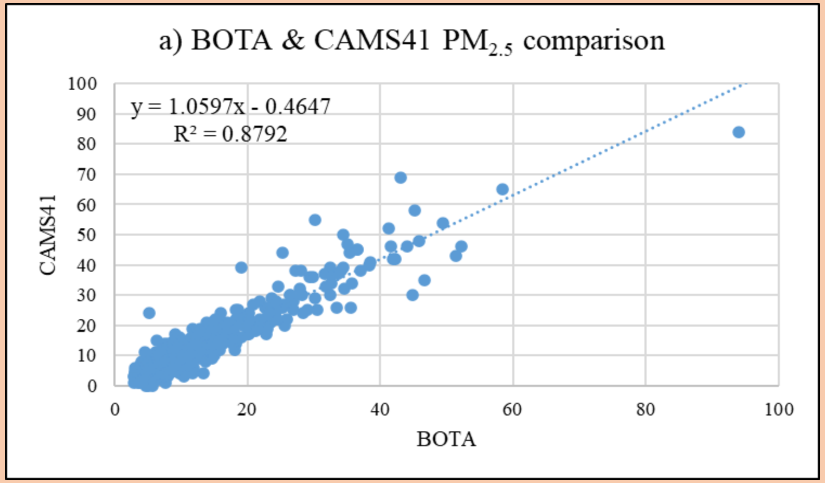
Comparison of BOTA to CAMS 41

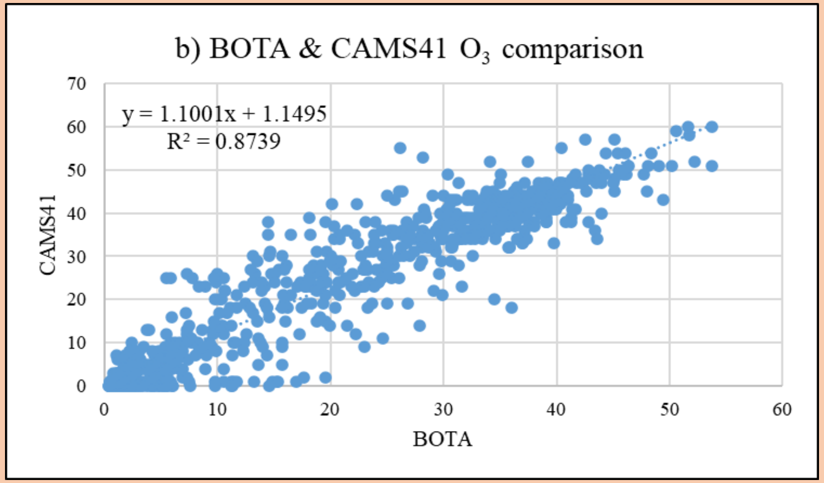


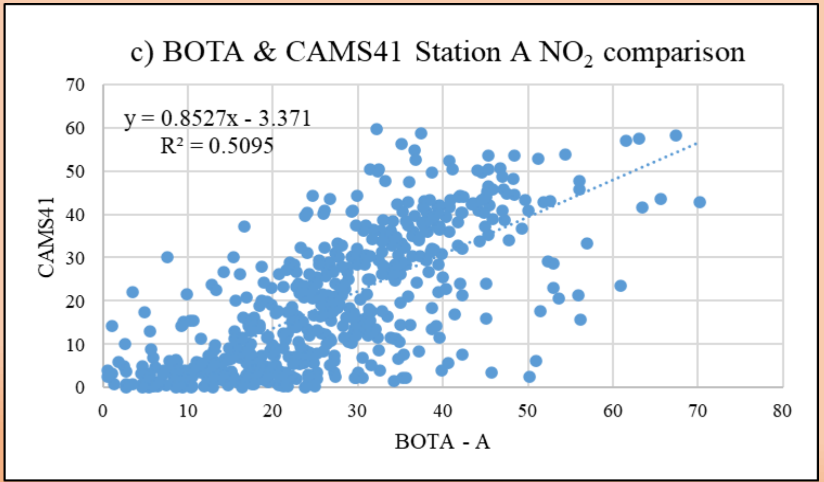


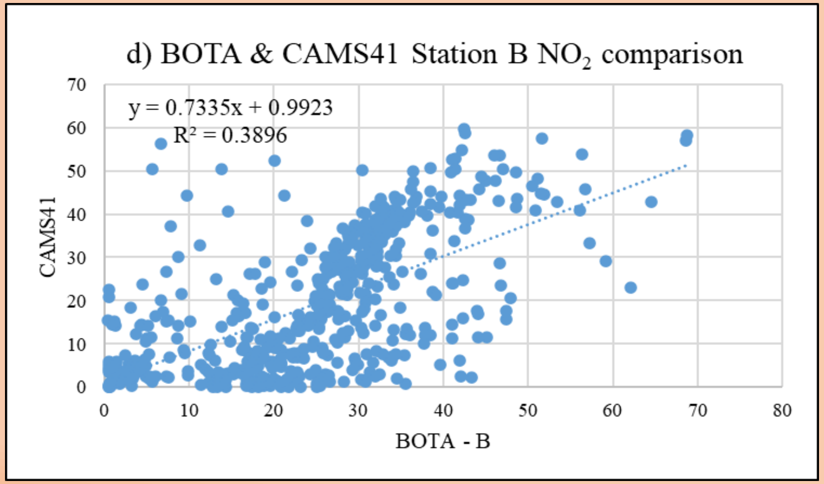


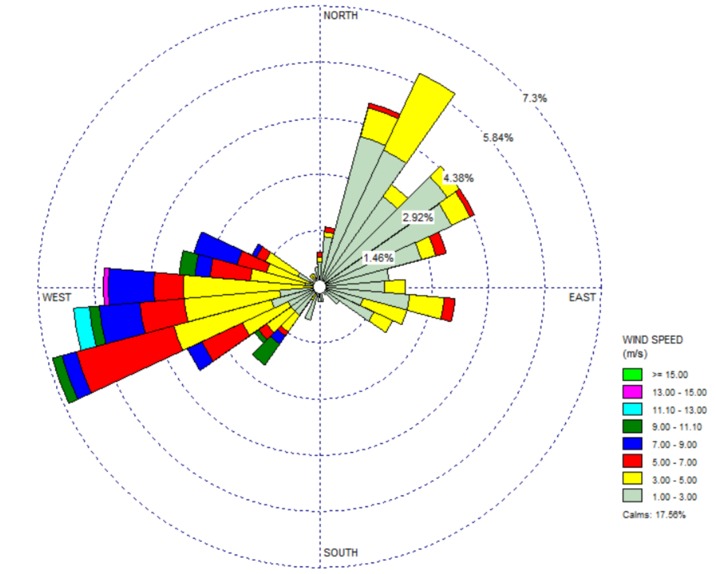
Comparison of BOTA to CAMS 41











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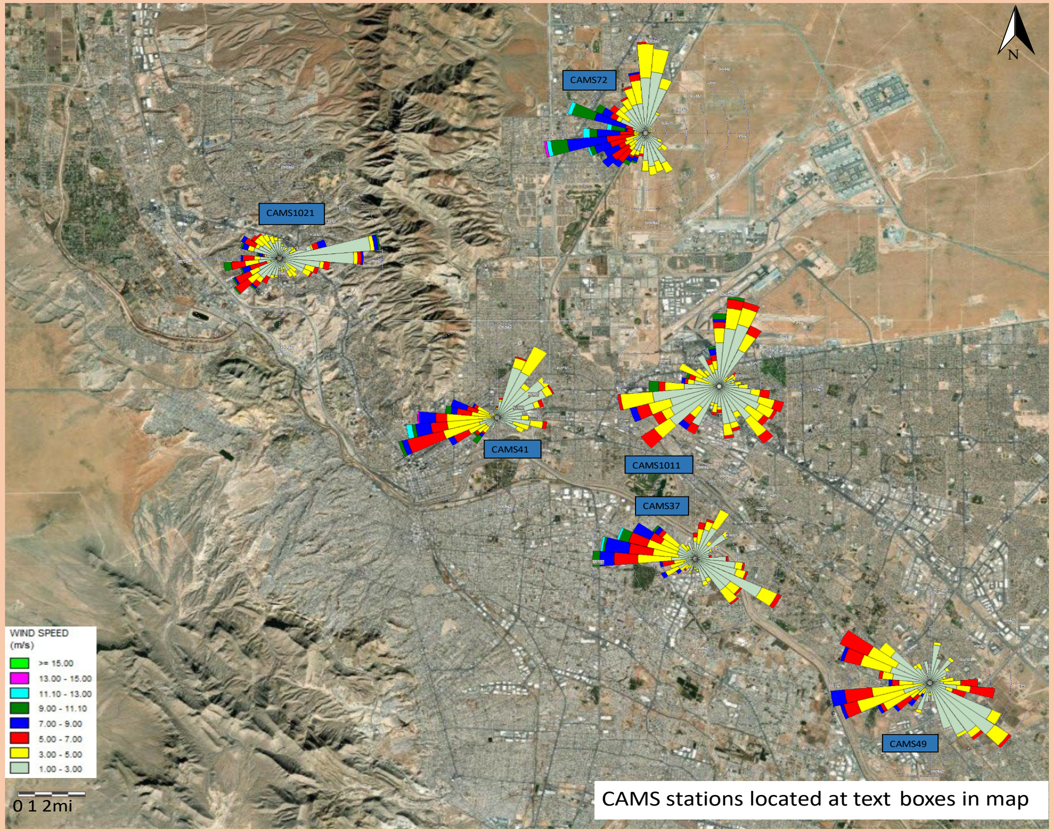
Comparison of BOTA to Other PdN FRM Locations

Period Average							
Measurement	BOTA	CAMS41	CAMS37	CAMS49	CAMS72	CAMS1011	CAMS1021
$PM_{2.5}$ ($\mu g/m^3$)	**11.6**	11.4	–	9.2	–	–	–
O_3 (ppb)	**22.2**	25.5	24.1	24.9	32.7	–	33.4
NO_2 (ppb) A	**24.0**	18.7	15.5	–	–	15.1	–
NO_2 (ppb) B	**23.1**						
Distance from BOTA (km)	–	0.4	5.1	18.2	14.3	4.2	14.0

Period Median							
Measurement	BOTA	CAMS41	CAMS37	CAMS49	CAMS72	CAMS1011	CAMS1021
$PM_{2.5}$ ($\mu g/m^3$)	**8.1**	8.0	–	7.4	–	–	–
O_3 (ppb)	**24.0**	29.5	28.0	27.0	37.0	–	38.0
NO_2 (ppb) A	**23.3**	15.3	11.6	–	–	10.2	–
NO_2 (ppb) B	**23.7**						
Distance from BOTA (km)	–	0.4	5.1	18.2	14.3	4.2	14.0



Comparison of BOTA to NAAQS

- Acceptable levels of $PM_{2.5}$, O_3, and NO_2 at BOTA pose no health hazards to the POE workers and users during the study period
- On-road, in-traffic O_3 and NO_2 were almost at background levels
- ~2% decrease in 0.4 miles in mean or median $PM_{2.5}$, or ~20% decrease in mean or ~9% in median in 18 miles.
- On-road, in-traffic concentrations are less affected by the variability in local vehicle emissions, traffic, and meteorological conditions due to the prevalence of urban background PM and O_3 concentrations, as also reported in San Diego and Australia

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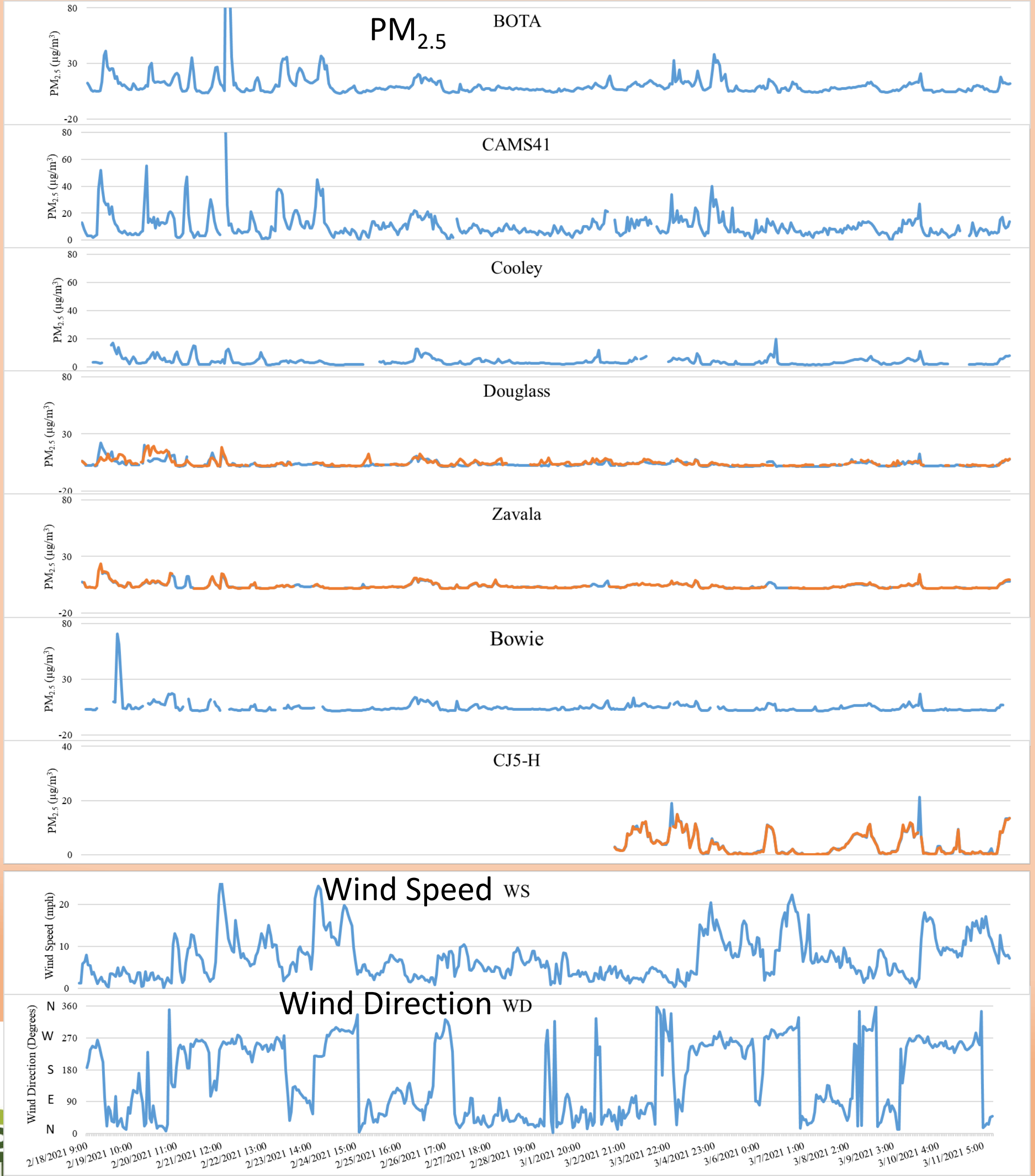
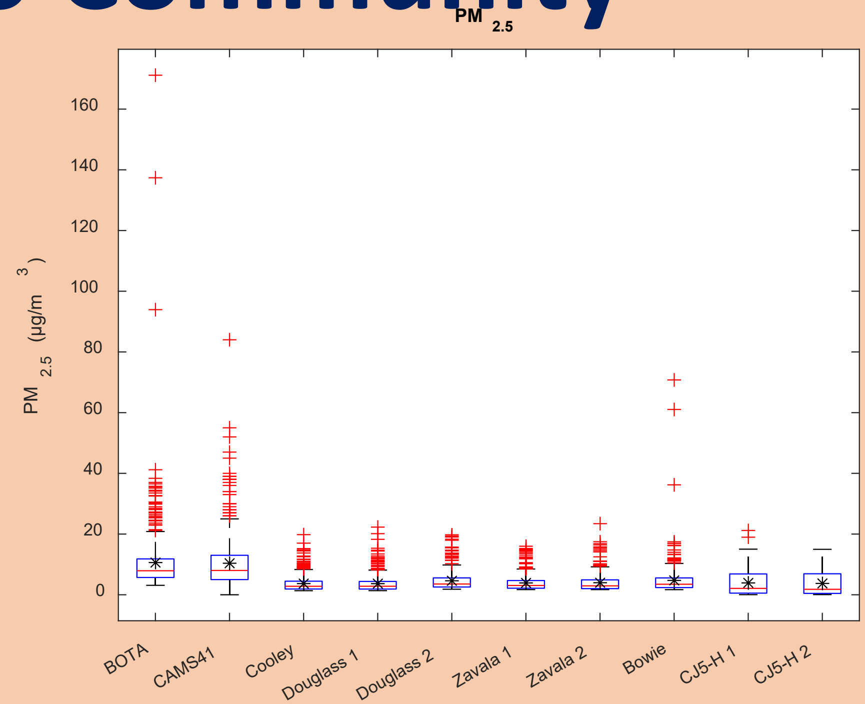
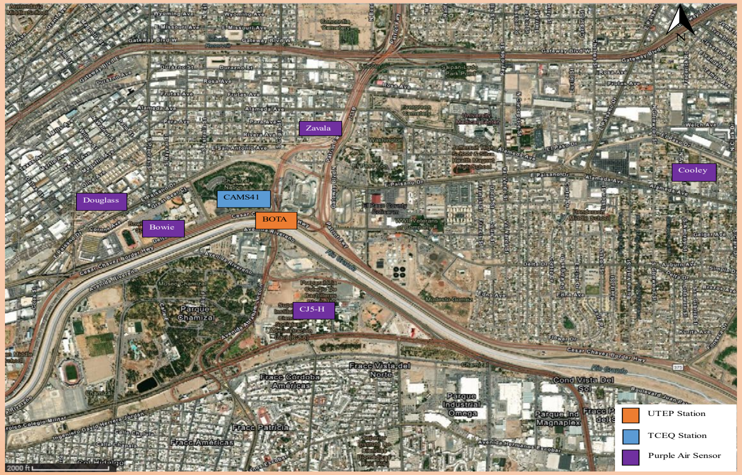
Comparison of BOTA to Community







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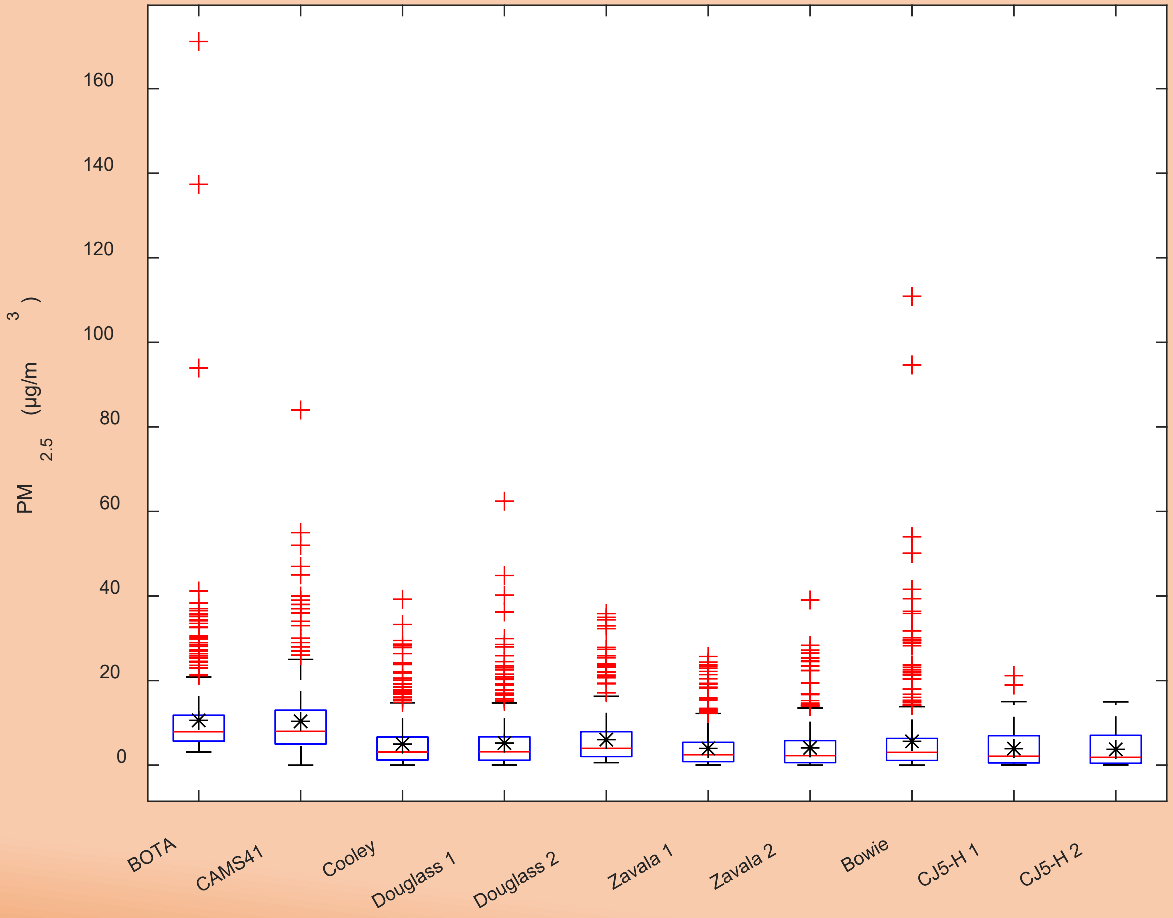
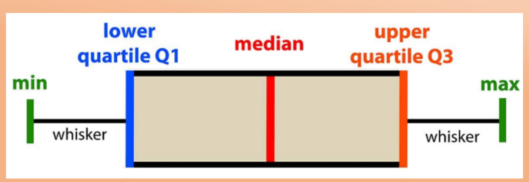
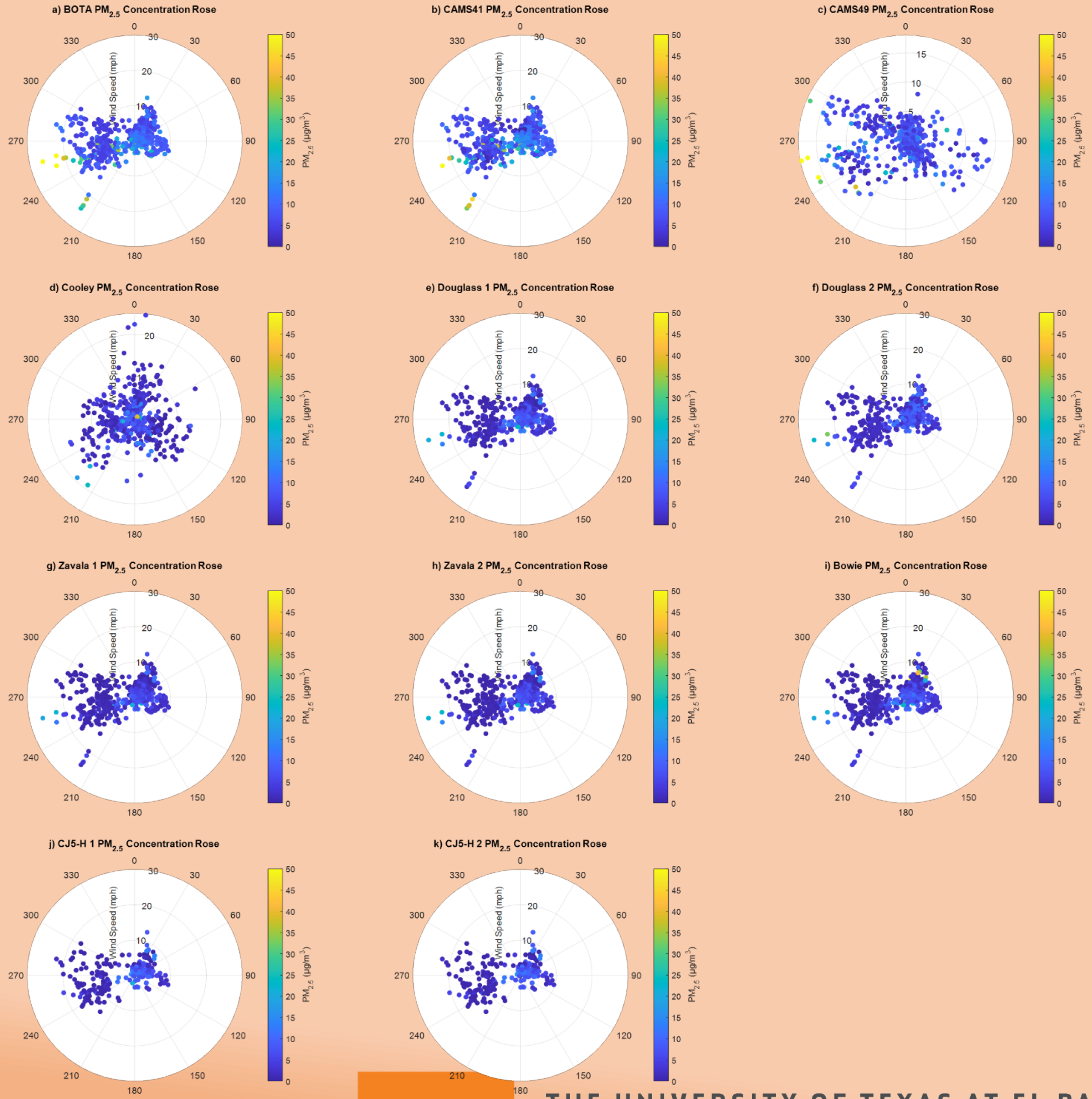
Community PM Data







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Comparison of BOTA to Community $PM_{2.5}$

- Low $PM_{2.5}$ was observed in the community, especially lower than those observed at FRM stations
- Low-cost $PM_{2.5}$ sensors are capable of catching PM peaks but less sensitive to low concentrations, likely due to variability in humidity, temperature, location of sensor, and PM characteristics in dry arid region which are different from other regions
- Low $PM_{2.5}$ in the community implies the prevalence of background concentration in the region

Summary

- Exposure concentrations of $PM_{2.5}$, O_3, and NO_2 for POE workers and users were less than their respective NAAQS during the study period indicating that exposure concentrations on the BOTA are in line with those observed 0.4 miles removed from the BOTA.
- The impacts of BOTA emissions on the local community are basically negligible, or pollutant concentrations are at the same level as those immediately inside the BOTA POE.
- The performance of all three FEM devices was determined to be in excellent agreement with that of the collocated FRM instruments
- Performance and accuracy of the low-cost sensors appear to be less reliable during our study although the devices were capable of detecting the trends and variability in pollutant concentrations in real time.

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Future Research

- Apply AERMOD air dispersion model, on-site meteorological data, and dilution ratios to estimate emissions from the BOTA
- Evaluate MOVES performance against emissions estimated from on-site concentrations
- Apply AERMOD air dispersion model to assess the impacts of BOTA emissions on near-road community
- Further on-road and near-road studies on commercial lanes and at other POEs

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Comments and Questions

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