IMPACTS OF ENCORE CASINO ON AIR QUALITY AND TRAFFIC VOLUME IN SOMERVILLE, MASSACHUSETTS: BASELINE CHARACTERIZATION (2018-2019)

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Prepared for:

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The cover image on previous page shows a mural painted on the Shore Drive I-93 underpass.

Executive Summary

People residing in the vicinity of heavily trafficked roadways are exposed to elevated concentrations of traffic-related air pollution (TRAP). In a densely populated urban area like Somerville, such exposed populations may constitute a considerable fraction of the city's total population; therefore, the air quality impacts of current and future traffic burdens merit monitoring and characterization. In this study we characterized air quality in eastern Somerville in the traffic corridor anticipated to be impacted by vehicles driving to and from the new Encore Casino in Everett. Our goal was to develop an understanding of the impacts of traffic emissions on air quality at baseline, in the year prior to the casino opening for business.

To accomplish our goal we defined a study area and mobile-monitoring route that included roadways near the confluence of Routes 28 and 38 and Interstate Highway I-93 as well as in adjacent neighborhoods. The monitoring route was X-miles in length and included both major arterial roadways and quiet residential streets. We monitored air quality using a state-of-the-art mobile monitoring platform consisting of an electric vehicle equipped with fast-response instruments, which were powered by batteries and an onboard DC-to-AC converter. The instruments measured ultrafine particles, black carbon, nitric oxide, carbon dioxide and PM2.5. at 1-second to 1-minute intervals. We monitored air quality in 3-5-hour windows during both traffic-peak and non-traffic-peak hours on weekdays and weekend days during three, two-month periods in the Summer and Fall of 2018 and the Winter of 2019. We estimated traffic speed and volume within the study area by analyzing cellphone data records (i.e., the location of cellphones over time) obtained from a third-party provider.

We measured air quality on 26 weekdays and 14 weekend days during the six-month monitoring period, completing 191 circuits of the mobile monitoring route and collecting over three million individual measurements. Our main findings include the following: (1) ultrafine particle number concentrations (PNC) were higher in winter than in summer and fall, while black carbon (BC) and nitric oxide (NO) concentrations were higher in summer and fall than in winter; (2) the concentrations of all three pollutants were generally higher on weekdays than on weekends; (3) PNC and BC concentrations were generally higher when winds were from the southeast, while NO concentrations were higher when winds were from the north; and (4) the concentrations of all pollutants were higher on busy arterial roadways than on residential streets.

This large dataset, collected in the year prior to the opening of the Encore Casino, provides a baseline of traffic and TRAP information against which changes traffic and air quality can be compared. We recommend that future studies of traffic and air pollution in Somerville be undertaken in such a way as to take full advantage of the methods we developed and the results we obtained in this study.

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Acknowledgements

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Introduction

Background and Objectives

The City of Somerville, MA, USA (pop. 76,000) is home to several highways and major roadways as well as a dense grid of surface streets that line its many residential neighborhoods. Three highways, Interstate 93 (I-93) and Massachusetts State Highways 28 and 38, which are among the busiest roadways in the Boston metropolitan area, together carry over 200,000 vehicles per day through the city.[1] Because these highways are located in the eastern part of Somerville, nearby neighborhoods are disproportionately impacted by roadway congestion and traffic-related air pollution.

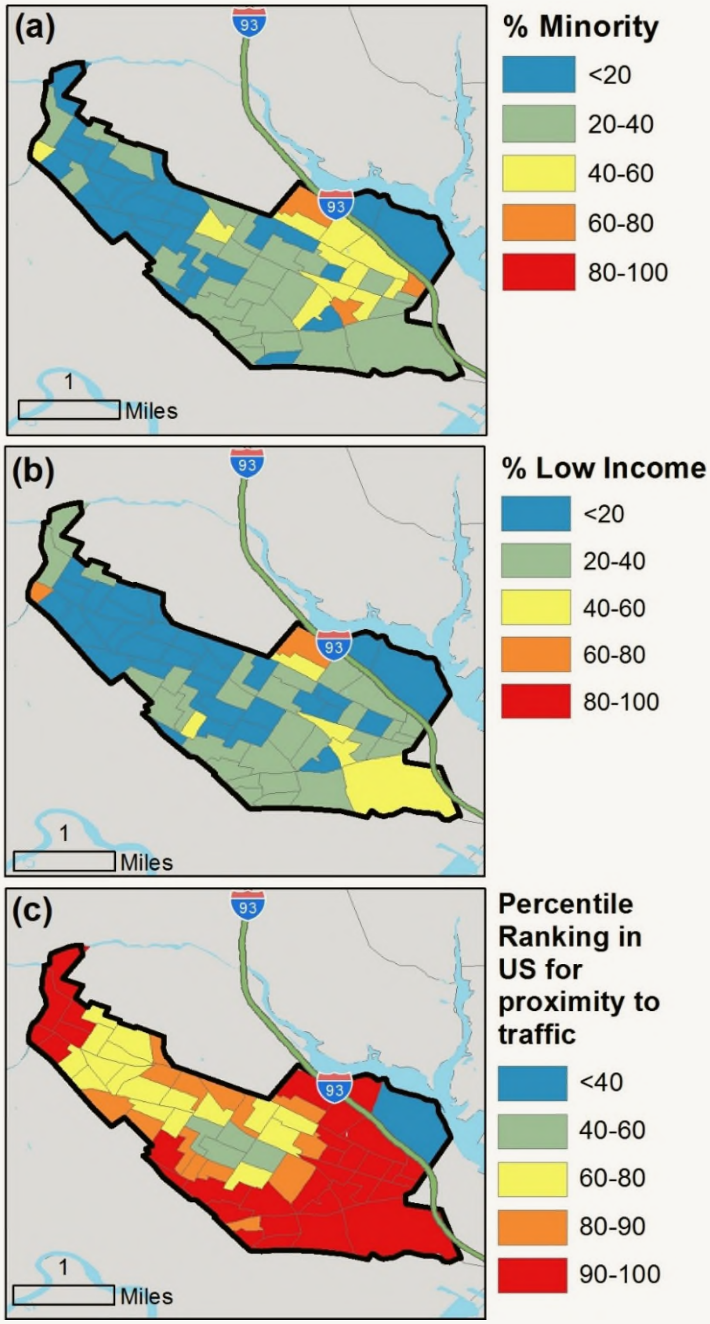

Figure 1: Percentile rankings for block groups in Somerville compared to block groups in the US for two demographic indicators (percent of population considered minority and percent of population considered low-income (a and b)) and an environmental indicator (proximity to traffic; c).

Figure 1 shows percentile rankings for block groups[2] in Somerville (compared to all block groups is US) for percent of population considered minority (a), percent of population considered low-income[3] (b), and an environmental

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[1] Traffic Volumes | Boston Region MPO https://www.ctps.org/subjects/traffic-volumes

[2] Data was obtained from US EPA's EJSCREEN (https://www.epa.gov/ejscreen)

[3] Overview of Demographic Indicators in EJSCREEN | EJSCREEN: Environmental Justice Screening and Mapping Tool | US EPA https://www.epa.gov/ejscreen/overview-demographic-indicators-ejscreen

indicator that is part of EPA's EJ index (proximity to traffic; (c)).[4] As is evident from these maps, there is a greater percentage of minority and low-income populations living near highways in Somerville. Nearly all block groups rank high for proximity to traffic but the block groups closest to I-93 and Routes 28 & 38 rank among the highest in US (> 90th percentile).

Added to this backdrop of a community that is already highly impacted by traffic-emissions, the development of Encore Casino in Everett, less than a mile from eastern Somerville across the Mystic River, is expected to bring additional traffic to the area. The casino complex – with its 671-room hotel, 18 restaurants, stores, boutiques, and live performance venue – is expected to draw an estimated 37,000-44,000 automobile trips per day (per Certificate of the Secretary of Energy and Environmental Affairs on the Supplemental Final Environmental Impact Report).[5] While much of this traffic was anticipated to arrive at the casino from the northeast and southeast (and thereby not impact roadways in Somerville), a significant fraction of the traffic could use I-93 and Routes 28 and 38 as they approach the casino from the northwest and southwest.

There is concern that this additional traffic will result in increased congestion on roadways and increased air quality impacts in neighborhoods in eastern Somerville. To better understand these impacts, the city commissioned this baseline study to characterize air quality and traffic in areas of Somerville that will likely be impacted by air pollution from traffic going to and from the casino. The goal of our effort is to analyze air quality and traffic volume at baseline, before June 23, 2019 when the casino opened for business. Our specific objectives were as follows:

1. Using a mobile monitoring approach, characterize baseline (pre-casino) air quality in areas of eastern Somerville most likely to be impacted by emissions from casino traffic;
2. Analyze the air quality data as well as contemporaneous traffic data and report characteristic features of spatial and temporal trends in the study area;
3. Recommend a study design to track changes in traffic volume and air quality in future years.

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[4] Overview of Environmental Indicators in EJSCREEN | EJSCREEN: Environmental Justice Screening and Mapping Tool | US EPA https://www.epa.gov/ejscreen/overview-environmental-indicators-ejscreen

[5] http://eeaonline.eea.state.ma.us/EEA/emepa/mepadocs/2015/040815em/sc/eir/15060sfeir%20Wynn%20Everett%20Casino.pdf

In the remainder of the Introduction we describe our rationale for selecting which pollutants to measure and which traffic metrics to analyze. Then, in the following sections we describe our study design and results for characterizing baseline, one year prior to the opening of the casino (March 2018 to June 2019).

Traffic-Related Air Pollution (TRAP)

Traffic-related air pollution (TRAP) refers to air pollution derived from primary emissions due to fuel combustion by motor vehicles including gasoline-powered passenger cars, diesel trucks and buses, and non-road equipment (e.g., construction vehicles). TRAP also contains non-tail-pipe emissions including tire and brake wear and resuspended road dust. The concentrations of TRAP can be as much as 10 times higher on or near roadways compared to urban background concentrations.[6] As a result, people residing in the vicinity of heavily trafficked roadways or travelling on them are routinely exposed to elevated concentrations of TRAP. Traffic-related air pollution is of concern because studies have shown that exposure to TRAP near major roadways and highways is associated with adverse health effects including cardiopulmonary disease, asthma and reduced lung function.[7-8]

Because TRAP contains a complex mixture of hundreds of different chemical components, it is not practical or feasible to measure all the components; therefore, surrogates of TRAP are typically used for assessing the contribution of traffic emissions to ambient air pollution and for estimating traffic exposures. The most commonly used TRAP surrogates include carbon monoxide (CO), nitrogen dioxide (NO_2), elemental carbon (EC; or black carbon [BC] or black smoke [BS]), benzene, and ultrafine particles (UFP; particles with aerodynamic diameter <100 nanometers).

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[6] Karner, A. A.; Eisinger, D. S.; Niemeier, D. A. Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data. *Environ. Sci. Technol.* **2010**, *44* (14), 5334–5344. https://doi.org/10.1021/es100008x.

[7] Health Effects Institute. Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects | Health Effects Institute. (2010). Available at: https://www.healtheffects.org/publication/traffic-related-air-pollution-critical-review-literature-emissions-exposure-and-health.

[8] Matz, C. J. *et al.* Human health effects of traffic-related air pollution (TRAP): A scoping review protocol. *Systematic Reviews* **8**, 223 (2019).

Ultrafine particles are of considerable interest for their possible role in disease causation for three reasons: they are present in very high concentrations in combustion emissions, they are more toxic per unit mass than particles with larger diameters, and once inhaled they can be translocated throughout the body due to their small size (<100 nm). For comparison, a human hair diameter is about 70,000 nm, so these particles are invisible and do not scatter light by themselves. Concentrations are measured after condensing a fluid onto them and growing the particles to light-scattering size in a "Condensation Particle Counter" or CPC and reported as particle number concentration (PNC) or number of particles/cm^3. Ultrafine particles are good indicators of fresh combustion emissions; however, they are as yet unregulated. Black carbon is a carcinogenic mixture of chemicals[9] produced during incomplete combustion, largely by diesel engines. Exhaust emissions from ground transportation gasoline engines are primarily in the form of NO, which upon release to the atmosphere is oxidized to NO_2 in the presence of ozone.

In this report we focus on three key air pollutants commonly present in TRAP mixtures: UFP, BC, nitric oxide (NO). Studies have shown that concentrations of these pollutants are elevated near highways and major roadways, but then decrease to background within several hundred meters. The factors that impact the magnitude and extent of roadway-to-background concentration gradients include traffic conditions, wind direction and speed, atmospheric stability, mixing height, temperature, relative humidity, and topography. We have designed our monitoring program to capture the influence of these factors in influencing concentration gradients near busy roadways in the study area. We also report on carbon dioxide (CO_2) and $PM_{2.5}$ (the latter is a regulated criteria pollutant[10] and is generally well mixed regionally).

Traffic Data

When new developments are being considered in urban areas of Massachusetts, transportation planners often use publicly available datasets and models to estimate the impacts of the proposed development on traffic patterns in surrounding neighborhoods. For example, the Massachusetts Department of Transportation generates Annual Average Daily Traffic (AADT)

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[9] *Health effects of black carbon*. (World Health Organization, Regional Office for Europe, 2012).

[10] https://www.epa.gov/criteria-air-pollutants/naaqs-table

estimates as well as other traffic information for highways and major roadways in Massachusetts[11]. These estimates are based on traffic data collection programs designed to measure traffic volume at specific and repeatable points for limited periods of time each year. While AADT is useful for understanding broad spatial variations in traffic patterns across a metropolitan area, and particularly on major roadways, it is less useful for revealing fine-grained diurnal and day-of-week impacts of proposed developments on nearby roadways. Similarly, the Boston Region Metropolitan Planning Organization maintains regional travel demand models (including traffic flow at the zonal level) and traffic volume models, which are based on historical travel survey and traffic count data. These models are reliable for long-term planning purposes; however, they are not designed to accurately predict rapid changes in traffic for specific roadways.

To complement these approaches, we sought to use newly available datasets to generate more finely spatially and temporally resolved traffic information for our study area. As a result of recent advances in ubiquitous sensing technologies and wide adoption of mobile phones, researchers have begun to investigate the use of mobile phone data to study travel behavior, urban mobility, travel demand, and road usage patterns.[12,13,14] For example, with the high penetration of smart phone devices, location-based service (LBS) data, based on app usage, could provide more accurate spatial trajectories of users, and thus offer a great opportunity to estimate traffic patterns with high space-time granularity. LBS mobile device data are enabled by GPS, Wi-Fi, or cellular data networks, and provide higher data sampling rates compared with other mobile-device data, such as call data record (CDR) data. Recent studies have employed LBS data to understand travel behavior and visitation patterns to POIs in the U.S.[15] The LBS data is useful for identifying contributions of traffic generated by different destinations and thus controls for

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[11] https://www.mass.gov/traffic-volume-and-classification

[12] Wang, P., Hunter, T., Bayen, A. M., Schechtner, K. & González, M. C. Understanding road usage patterns in urban areas. *Sci. Rep.* **2**, 1–6 (2012).

[13] Jiang, S. *et al.* A review of urban computing for mobile phone traces: Current methods, challenges and opportunities. in *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* 1 (ACM Press, 2013). doi:10.1145/2505821.2505828

[14] Alexander, L., Jiang, S., Murga, M. & González, M. C. Origin-destination trips by purpose and time of day inferred from mobile phone data. *Transp. Res. Part C Emerg. Technol.* **58**, 240–250 (2015).

[15] Athey, S., Blei, D., Donnelly, R., Ruiz, F. & Schmidt, T. *Estimating Heterogeneous Consumer Preferences for Restaurants and Travel Time Using Mobile Location Data*. (2018).

traffic generated by urban development in the vicinity of the project of interest. Based on the successful use of LBS mobile device data in these studies, we decided to acquire LBS mobile device data for the Boston metropolitan area (including Somerville) for same time periods during which air quality monitoring was performed.

Methods

The method of air quality data collection used in this study was based on mobile monitoring, i.e., on-road measurements were made under real-world driving conditions with an electric mobile platform (equipped with rapid-response instruments) that provided direct assessment of on-road air quality. The mobile monitoring route was designed to characterize spatial contrasts in traffic-related air pollution within the study area, which consisted of both near-highway neighborhoods (i.e., <400 m from either side of I-93) and neighborhoods on and near Broadway Avenue and Route 28. Figure 2 shows the monitoring route with arrows showing the direction the TAPL was driven on in each road segment. The road class of each segment is also shown in Figure 2. Three intensive campaigns were conducted in different seasons: Summer (June-July) 2018, Fall (September-November) 2018 and Winter (January-February) 2019. During each campaign monitoring was performed on the days of week and hours expected to have a high flow of traffic to and from Encore Casino. These were identified as late afternoon to evening (1600-2000 hours) on Thursday and Friday and late morning to midday (1100-1500 hours) on Saturdays and Sundays. Days and times of monitoring are summarized in

Table 6. Summarily, air quality monitoring was conducted on 14 days during the summer 2018 campaign, 11 days during the fall 2018 campaign, and 15 days during the winter 2019 campaign (Table 6). These 40 days included 13 Thursdays, 12 Fridays, nine Saturdays, five Sundays, and one Tuesday. In total 191 loops were driven around the monitoring route: 72 in summer, 53 in fall and 66 in winter.

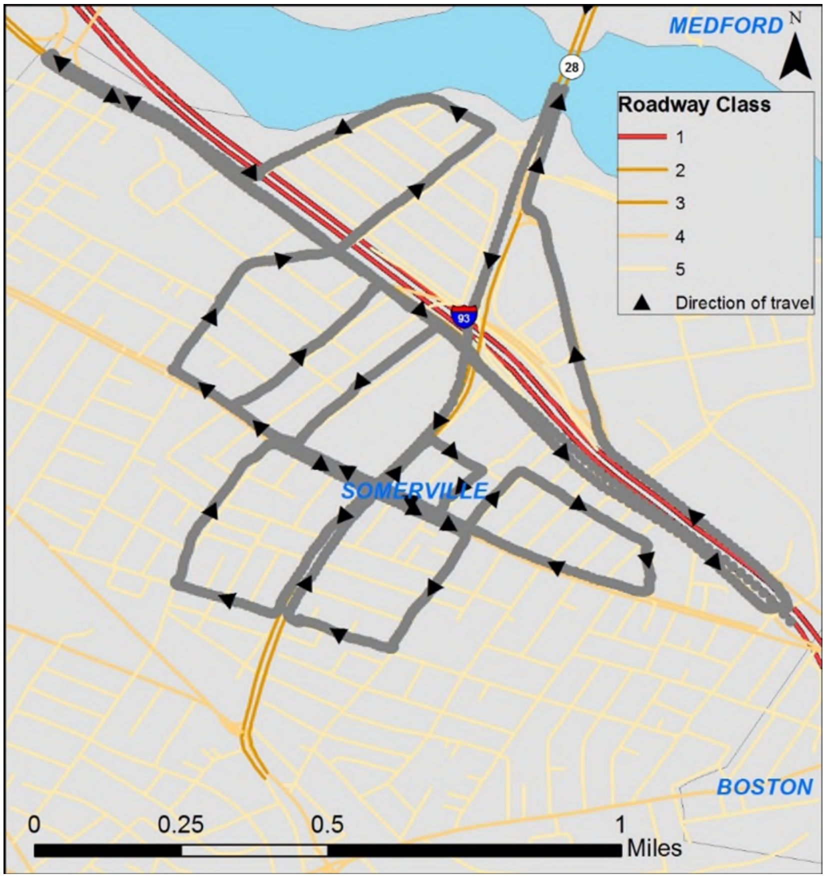

Figure 2: Mobile-monitoring route with arrows indicating the direction of travel.

We obtained anonymous Location-Based Service (LBS) mobile phone data in high spatial resolution (~10 to 100 meters) for one million mobile phone users in the Boston region (20% of the total population) for summer (June-July 2018), fall (October-November 2018), and winter months (January-February 2019). We purchased this data from a technology company (through a non-disclosure agreement) that collects locational information from anonymous users who have agreed to share their location information. We used the data to estimate traffic speed and traffic volume by time of day and day of the week for each two-month period for specific road segments within the study area. To extract traffic volume and speed information, we first estimated the travel modes (walking, biking, driving) of each mobile phone user in the LBS dataset for each segment of their trips during the six-month period. Each device-specific entry in the dataset contained a time stamp (in hours/minutes/seconds) as well as latitude and longitude every time a mobile-phone application was in active or passive use (i.e., every few seconds). We applied the following algorithms to estimate the travel mode of each user's travel behavior.

Methods are described in greater detail in the technical appendix.

Results and Discussion

Although there was considerable spatial and temporal variation in air quality within the study area, and example is shown in Figure 3 (also see Figures 10-17). Several patterns can be seen in the data as described below.

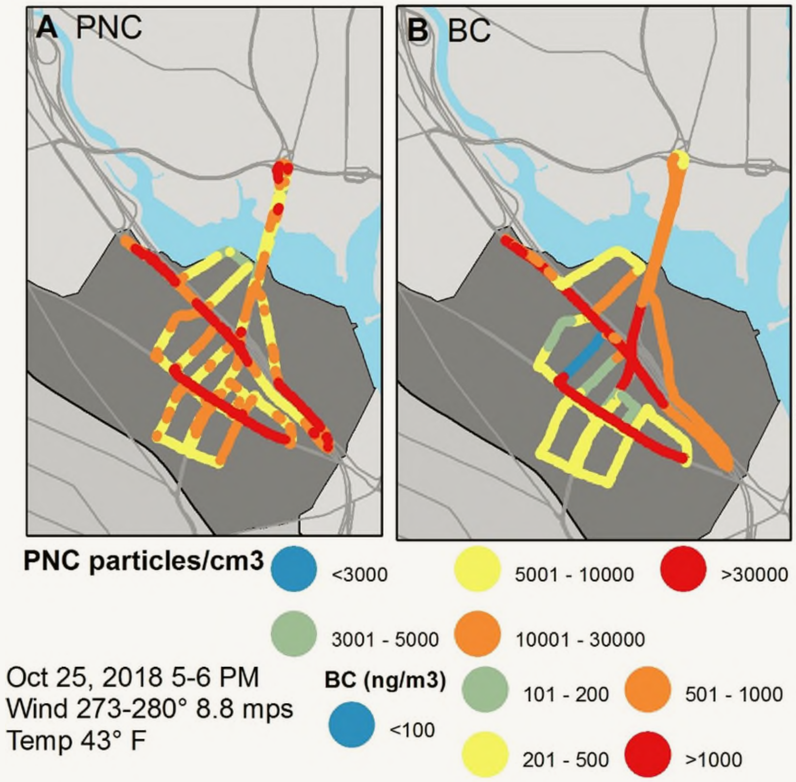

Figure 3: An example of the spatial trend observed in Somerville, MA during the monitoring campaign. (a) particle number concentration (PNC) and (b) black carbon (BC) spatial patterns are shown for October 25, 2010 during weekday evening rushhour (5-6 PM). For interpretation of colors, see

1. Total on-road concentrations were generally higher on Class 2 and 3 roadways than on Class 4 or Class 5 roadways for all pollutants in all three seasons (Tables 1-3).
2. Background concentrations varied by season for PNC and BC, but not NO (Tables 1-3). Background for PNC was lowest in the summer and highest in fall and winter (Table 1). BC background was lowest in the winter and highest in the fall with summer concentrations being lower than fall, but only modestly so (Table 2). We did not observe a seasonal trend in the background concentrations for NO (Table 3). Traffic contribution to the total concentrations were highest for Class 2 & 3 roadways and lowest for Class 5. On Class 4 roadways, the traffic contribution was similar to that observed on Class 2 & 3 roadways. See Tables 1-3.

Table 1: Summary of particle number concentration (PNC) measurements by season and road class.

Season	Road Class	PNC (particles/cm^3)				
		Median Background	Total On-road		Traffic Contribution	
			Median	Mean	Median - Background	Mean - Background
Summer	2&3	7000	11600	19200	4600	12200
Summer	4	7100	11600	18100	4500	11000
Summer	5	6400	9800	16000	3500	9600
Fall	2&3	10200	16700	25600	6500	12000
Fall	4	9900	18100	26200	6800	12100
Fall	5	9600	15200	20400	5200	9100
Winter	2&3	9700	19200	29700	7700	12800
Winter	4	10600	18300	25700	7100	11900
Winter	5	10400	15400	22900	5000	8200

Notes: Median is the median of median concentrations observed on all roadways of a road class per loop (i.e., all the roads in a particular class for the entire loop contribute one median value and then the median of those medians is reported here). Similarly, the mean value is the mean of means. The background is the median of the 5th percentile values.

Table 2: Summary of black carbon (BC) concentration measurements by season and road class.

Season	Road Class	BC (ng/m^3)				
		Median Background	Total On-road		Traffic Contribution	
			Median	Mean	Median - Background	Mean - Background
Summer	2&3	330	720	860	390	520
Summer	4	350	640	850	290	490
Summer	5	330	530	680	200	350
Fall	2&3	430	720	1040	280	430
Fall	4	370	660	1150	260	420
Fall	5	300	490	850	180	320
Winter	2&3	110	360	530	240	350
Winter	4	120	380	470	220	300
Winter	5	100	240	380	160	210

Notes: Median is the median of median concentration observed on all roadways of a road class per loop (i.e., all the roads in a particular class for the entire loop contribute one median value and then the median of those medians is reported here). Similarly, the mean value is the mean of means. The background value is the median of the 5th percentile value.

Table 3: Summary of nitric oxide (NO) concentration measurements by season and road class.

Season	Road Class	NO (ppb)				
		Median Background	Total On-road		Traffic Contribution	
			Median	Mean	Median - Background	Mean - Background
Summer	2&3	5	10	13	5	8
Summer	4	5	10	16	5	11
Summer	5	5	10	15	5	10
Fall	2&3	5	11	18	6	13
Fall	4	5	11	18	6	13
Fall	5	5	10	18	5	13
Winter	2&3	5	9	13	4	8
Winter	4	5	8	12	3	7
Winter	5	5	9	13	4	8

Notes: Median value is the median of median concentration observed on all roadways of a road class per loop (i.e., all the roads in a particular class for the entire loop contribute one median value and then the median of those medians is reported here). Similarly, the mean value is the mean of means. The background value is the median of the 5th percentile value.

3. For PNC, the lowest concentrations were observed in summer and the highest concentrations in winter (Figure 4(a)). In contrast, for BC (Figure 4(b)) and NO, we observed similar concentrations in summer and fall and lower concentrations in winter.

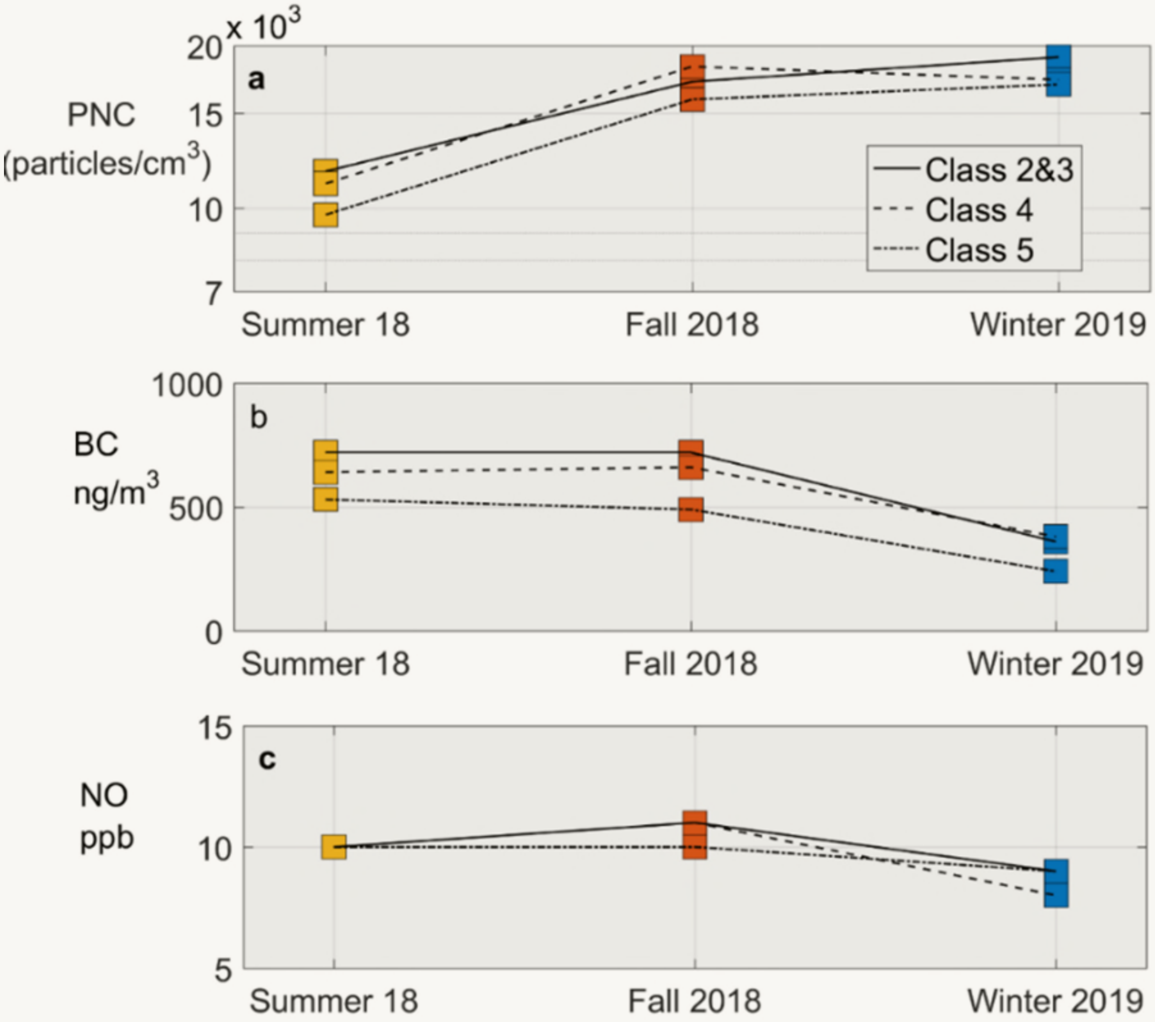

Figure 4. Seasonal medians for (a) PNC, (b) BC, and (c) NO concentration for different roadway classes in the study area. Each colored square represents the seasonal median of the median value of all measurements during a single lap of the monitoring route for a specific roadway class (see Tables 1-3).

4. In general, higher PN, BC and NO concentrations were observed during easterly winds, which orient most parts of Somerville downwind of I-93, and during north and south winds that are parallel to I-93. See Figure 5 and Table 7.

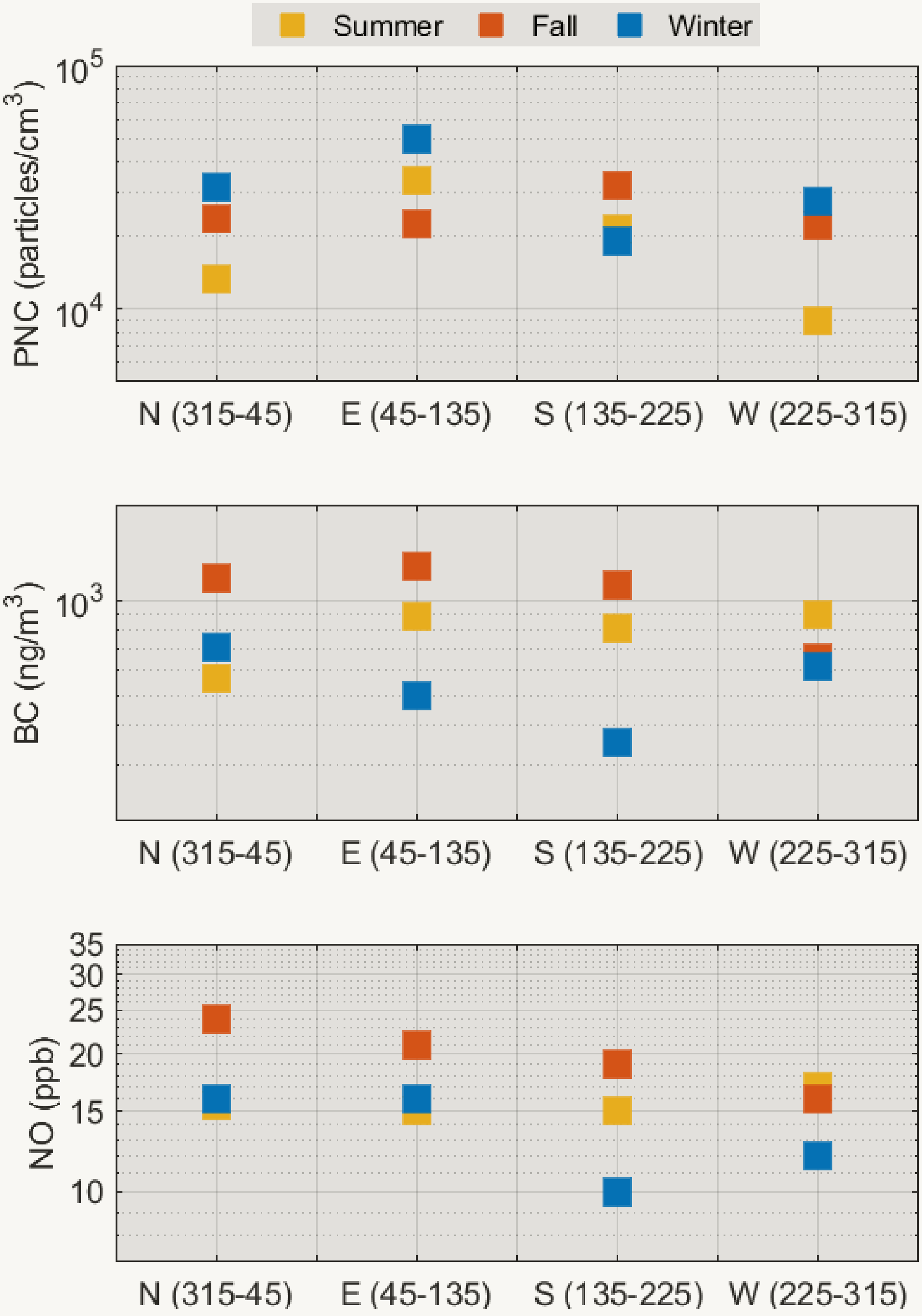

Figure 5: Mean PNC and mean BC and NO concentrations for four 90-degree-wide wind quadrants for the three seasonal campaigns. Each point represents mean of hourly mean; all data for the hour was assigned the vector averaged wind direction measured at Logan Airport, and then the mean of those hourly means was calculated and plotted. Also see Table 7.

5. Pollutant concentrations were on average higher on Thursday during PM rushhour than Fridays or on weekends (Figure 6). Hourly trend is shown in Figure 19. Also see Tables 8 and 9.

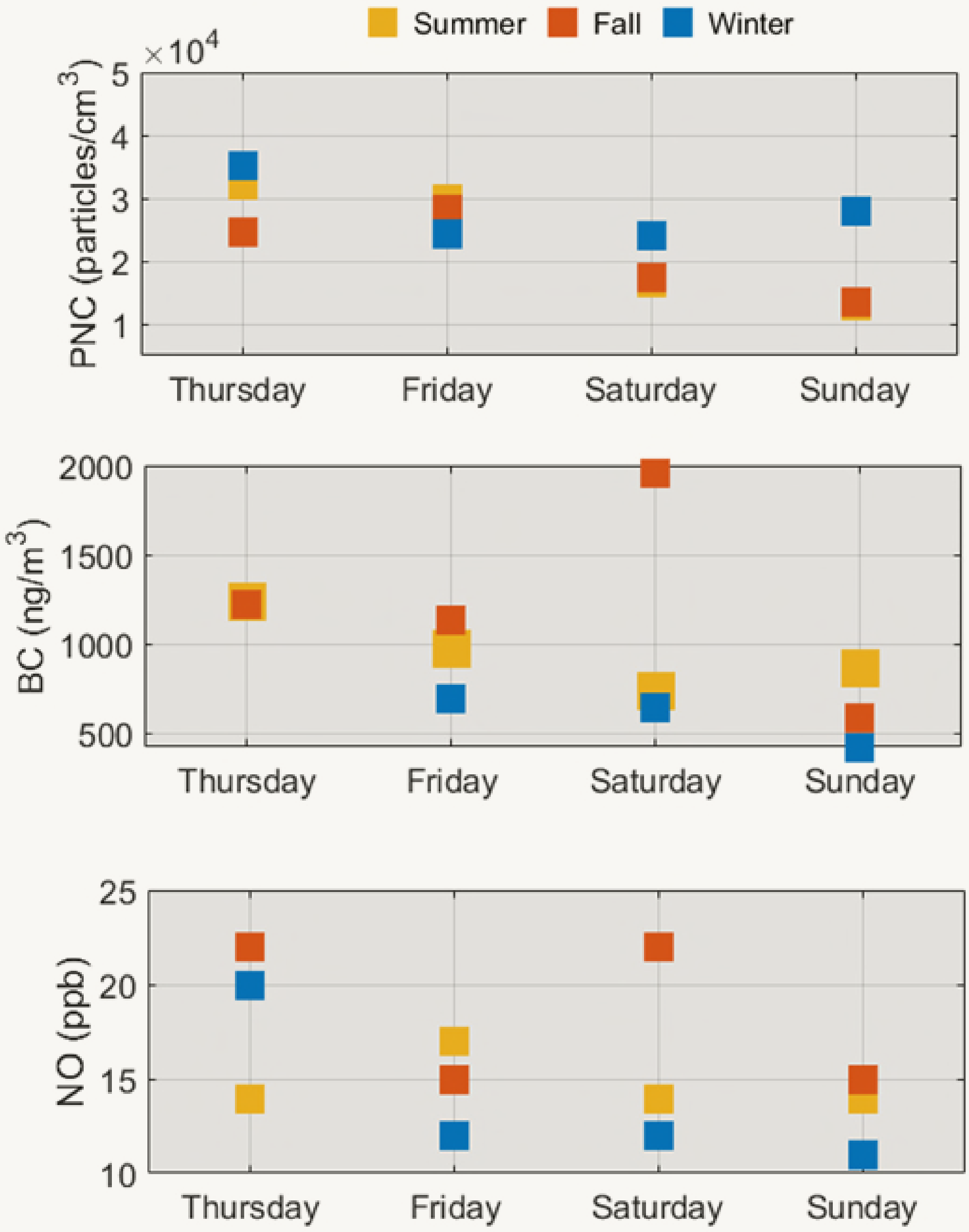

Figure 6: Mean PNC and mean BC and NO concentration for four different days of the week in the three seasonal campaigns. Also see Table 8.

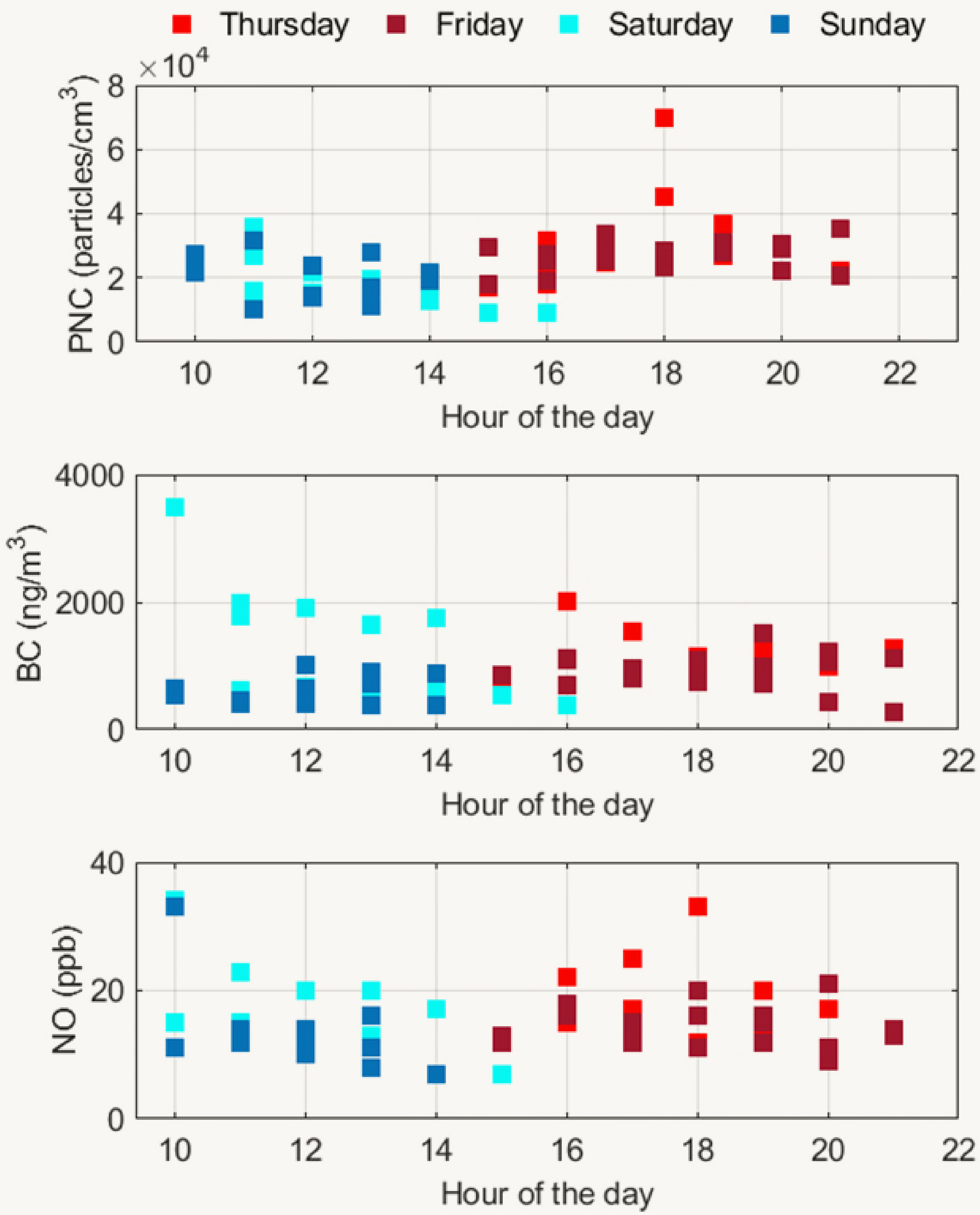

Figure 7: Mean PNC and mean BC and NO concentration for four different days of the week averaged by the hour. Also see Table 9.

6. Our estimation results on hourly traffic volume in peak hours (4-7 PM) and non-peak hours (7-9 PM) for an average Thursday and Friday, and hourly traffic volume in non-peak hours (10 AM - 2 PM) for an average Saturday or Sunday for the summer, fall and winter seasons in 2018 and 2019 are exhibited in Figures 18-23. The correlations between estimated traffic volumes and measured air quality concentrations were low (Figures 24-30). This may be due to differences in how the two datasets were collected: the air quality measurements reflect the true day-to-day and hour-to-hour influence of local traffic and meteorological conditions, while estimated traffic volumes are an average representation of a day or hour. As a result, there was considerably more variation/scatter in the air pollution data and less variation in estimated traffic volume.

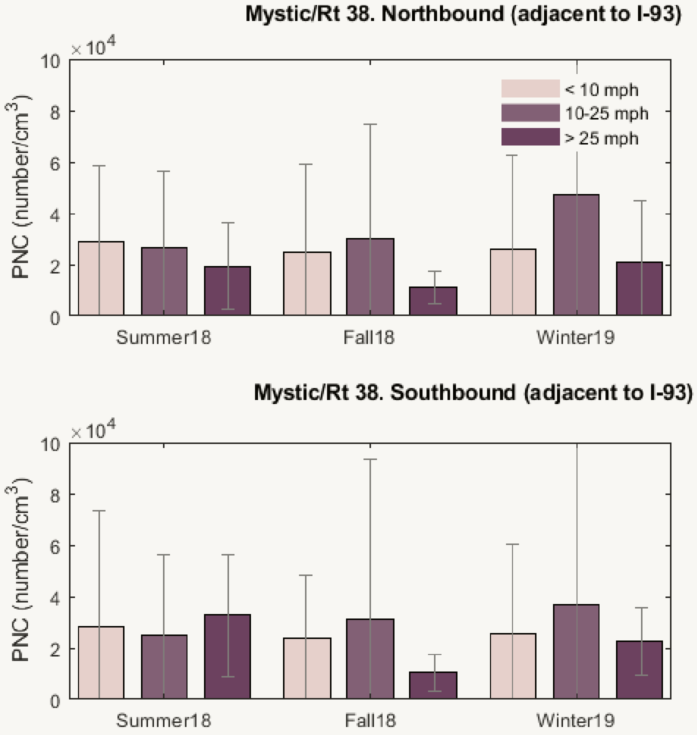

Figure 8: Particle number concentration (PNC) on Mystic Ave. which is adjacent to I-93 split by seasonal campaign and

Comparison to previous studies

Padro-Martinez et al[16] made measurements in Somerville in 2009-2010 on a nearly identical mobile-monitoring route to the one used in the current study. Mobile monitoring was performed on 18 winter days, 13 spring days, 12 summer days, and 12 fall days. The majority of monitoring was done on weekday mornings to allow characterization of worst-case conditions in terms of traffic volume (rush hour) and atmospheric mixing (the atmosphere is relatively stable near land surfaces in the morning).

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[16] Padró-martínez, L. T.; Patton, A. P.; Trull, J. B.; Zamore, W.; Brugge, D.; Durant, J. L. Mobile Monitoring of Particle Number Concentration and Other Traffic-Related Air Pollutants in a near-Highway Neighborhood over the Course of a Year. *Atmos. Chem. Phys.* **2012**, *61*, 253–264.

In that campaign, the median PNC within 0-50 m of I-93 was 37,000 particles/cm^3 and was 1.5-times higher than in both the 200-450 m bin on the northeast side of I-93 and the 100-150 m bin on the southwest side, and 2.1-times higher than ~18,000 particles/cm^3 in the 1000-1800 m distance range on the southwest side of the highway. Our measurements on Class 2 roadway – Mystic Ave. (Rt 38) – adjacent to I-93 and within 100 m are shown in Figure 8. We observed concentrations that were similar.

Recommendations

We recommend that future studies of traffic and air pollution in Somerville be undertaken in such a way as to take full advantage of the methods we developed and the results we obtained in this study. Future studies should be performed using mobile monitoring because it is the most singularly versatile method to capture both spatial and temporal variation of pollutant concentrations in the study area. To best leverage our findings, we recommend that the same pollutants (PNC, BC and NO) be measured (preferably with same or very similar, rapid response instruments) and that the same mobile monitoring route be driven. We also recommend that additional traffic studies be performed using simultaneously deployed traffic counters on Class 2, 3, 4, and 5 roadways along our mobile monitoring route. These deployments (24 hrs/day for several days at multiple sites) should be timed to coincide with intensive mobile monitoring (daily, 4-5 hours/day) to maximize the value of the traffic data for explaining the air pollution measurements. Finally, we recommend that a stationary site be established at a central location in the study area (preferably near the intersection of routes 28, 38, and I-93) so that a long-term record of air quality in the study area can be obtained. A weatherproof box with built in heating and cooling systems would allow for deployment in all seasons, and if the box is equipped with the same types of monitors as in the mobile lab, then direct comparisons of the mobile and stationary-site data can be made. The value of the stationary site data is that it affords greater understanding of the temporal changes in air quality over both short- (hours, days) and long-time intervals (weeks, months, seasons), and as such serves as a useful complement to mobile monitoring data.

Technical Appendix

Contents

Figures

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Methods

The study area, located in eastern Somerville, is ~1 km^2 in area (Figure 2). Land in the study area is mainly used for transportation, commercial, and residential purposes. The study area contains three highways: I-93 and Routes 28 (Fellsway) and 38 (Mystic Avenue). I-93 and Route 38 run parallel to one another as they traverse the study area from northwest to southeast; Route 28 crosses underneath I-93 and intersects with Route 38, bisecting the study area from northwest to southeast. There are two I-93 interchanges in the study area: exit 29 allows traffic on and off I-93 north at Assembly Square and exit 28 allows traffic on and off I-93 south at Sullivan Square (Figure 2). It is anticipated that much of the casino traffic in Somerville will use these three roadways.[17] The study area also contains Foss Park, the largest green space in the city, and Assembly Row, the largest mixed-use commercial/residential space in the city. The mobile monitoring route, which traversed the study area, was ~10 miles long and consisted of ~4 miles of Class 2 and Class 3 roadways (~2/3 of total length of these class in the City) and ~6 miles of Class 4 (>1/4 of total length of this class in the City) and Class 5 roadways (Table 1).

Table 4: Roadway classes on the mobile monitoring route.

Class	Description	Total length (mile)	Examples of roads on the route that belong to the class designation
1	Limited Access Highway		I-93; historical data available historical and post-baseline year but part of baseline year monitoring
2	Multi-lane Highway, not limited access	3.2	Fellsway West, McGrath Highway
3	Other numbered route	0.5	Mystic Avenue
4	Major road - arterials and collectors	2.3	Broadway, Middlesex Avenue
5	- Minor street or road (with Road Inventory information, not class 1-4)	3.7	Cross Street East, Garfield Avenue, Cross Street, Temple Road, Pennsylvania Avenue, Fellsway West, Grant Street, Pearl Street, Walnut Street, Shore Drive, Temple Street
6	Minor street or road (with minimal Road Inventory information and no street name)		

Note: in the City of Somerville there are a total of 4.9 miles of Class 1 roads, 4.3 miles of Class 2 roads, 1.4 miles of Class 3 roads, 22.4 miles of Class 4 roads, 91.6 miles of class 5 roads, and 0.7 miles of Class 6 roads.

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[17] MassGIS. MassGIS Data: Massachusetts Department of Transportation (MassDOT) Roads https://docs.digital.mass.gov/dataset/massgis-data-massachusetts-department-transportation-massdot-roads#Attributes.

A. Air Quality Methods

A.1 Mobile Monitoring

Accurate quantification of exposures to traffic-related air pollution in near-highway neighborhoods is challenging due to the high degree of spatial and temporal variation of pollutant concentrations. The method of air quality data collection used in this study was based on *mobile monitoring*, a well-established method that has been used in many near-roadway studies.[18],[19] On-road measurements made under real-world driving conditions with a mobile platform (equipped with rapid-response instruments) can provide direct assessment of on-road air quality. By driving the platform on a variety of streets – both heavily trafficked roadways and quiet residential streets – under different driving and meteorological conditions, insights can be gained on the factors that influence the spatial and temporal variation of TRAP. The benefit of this approach is that it enables fine spatial coverage directly on roadways of interest in a cost- and effort-effective manner compared to a single stationary site or even a network of stationary sites. Nonetheless, the greater spatial coverage afforded by mobile monitoring comes at the cost of sacrificing temporal resolution since mobile monitoring cannot be performed continuously. Because our goal was to measure baseline conditions on roadways in Somerville, we prioritized a broader spatial coverage to capture the spatial trends and adopted a mobile monitoring methodology; however, we monitored in different seasons, on different days of the week and at different times of day to better understand temporal trends, particularly those relevant to anticipated periods of heavy casino traffic.

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[18] Padró-Martínez, L. T.; Patton, A.P.; Trull, J.B.; Zamore, W.; Brugge, D.; Durant, J.L. Mobile Monitoring of Particle Number Concentration and Other Traffic-Related Air Pollutants in a near-Highway Neighborhood over the Course of a Year. *Atmos. Chem. Phys.* **2012**, *61*, 253–264.

[19] Patton, A. P.; Perkins, J.; Zamore, W.; Levy, J. I.; Brugge, D.; Durant, J. L. Spatial and Temporal Differences in Traffic-Related Air Pollution in Three Urban Neighborhoods near an Interstate Highway. *Atmos. Environ.* **2014**, *99*, 309–321. https://doi.org/10.1016/j.atmosenv.2014.09.072.

Figure 9: Tufts Air Pollution Monitoring Lab (TAPL) monitoring on Mystic Avenue in Somerville near I-93.

A.2 Instruments

Real-time measurements of air pollutants were made with the Tufts Air Pollution Monitoring Laboratory (TAPL), an electric-powered vehicle equipped with fast-response instruments for monitoring gas- and particle-phase pollutants (Figure 9). During monitoring, the TAPL was driven at the posted speed limit or at the travel speed afforded by traffic conditions on the roadways. The monitoring instruments used in TAPL are listed in Table 5. The gas analyzers were calibrated prior to the start of seasonal monitoring campaigns against reference gases at specified concentrations including zero air (i.e., air free of the monitored gases). Particle instruments underwent a flow rate and zero-concentration check prior to the start of the monitoring runs. Instrument clocks were set to National Institute of Standards and Time (NIST) clock before the start of the monitoring runs on each day of monitoring. Measurements were taken every 1 second to 1 minute depending on the instrument. Individual pollutant measurements were matched to location by 1-second-interval GPS readings.

Table 5: Air pollution monitoring equipment in the TAPL used for this study.

Parameter	Equipment; manufacturer/model	Detection Limit	Instrument reporting interval (sec)	Averaging time (sec)	Lag time (sec)
Particle number concentration (PNC), proxy for ultrafine particles (UFP)	Condensation Particle Counter (CPC) TSI (3783)	1 particle/cm^3 in the 7-3,000 nm size range	1	1	<3
PM2.5					
Nitric oxide (NO)	Chemiluminescence analyzer; Thermo Scientific 42i	0.40 ppb	1	20	30
Carbon dioxide (CO_2)	Non-dispersive infrared analyzer, Li-COR 840	<1 ppm signal noise at 370 ppm CO_2	1	1	N/A
Black carbon (BC)[20]	Aethalometer; Magee Scientific AE-33	10 ng/m^3	60	60	~40
Latitude/ Longitude	GPS receiver; Garmin GPS V	NA	1	1	0

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[20] The total optical absorption is measured simultaneously at seven wavelengths (370, 470, 520, 590, 660, 880, 950 nm) which varies by type of carbon compound. The data obtained from the sixth channel (measurement at 880 nm) is the defining standard used for reporting BC, considered to be composed of mostly elemental carbon or soot. UV-PM, i.e., 370 nm channel also spikes with traffic emissions.

A.3 Mobile Monitoring Route

The mobile monitoring route was designed to characterize spatial contrasts in traffic-related air pollution within the study area, which consisted of both near-highway neighborhoods (i.e., <400 m from either side of I-93) and neighborhoods on and near Broadway Avenue and Route 28. Figure 2 shows the monitoring route with arrows showing the direction the TAPL was driven on in each road segment. The road class of each segment is also shown in this figure. Each loop started at the Somerville/Medford line on Route 38. From there the TAPL was driven as follows:

(1) south on Route 38 to the I-93 underpass in east Somerville;
(2) north on Route 38 to the intersection with Middlesex Avenue;
(3) north on Middlesex Avenue to the intersection with Route 28;
(4) north on Route 28, across the Mystic River, followed by a U-turn at Wellington Circle, back across the river on Route 28 south, through the intersection with Route 38 to the intersection with Broadway Avenue;
(5) through three out of four leaves of a four-leaf-clover pattern (all right turns) around the Route 28/Broadway Avenue intersection;
(6) south on States Avenue through the States Avenues Neighborhood to the intersection with Broadway;
(7) north on Broadway to Grant St. followed by a series of right turns around the blocks nearest to Foss Park on its northwest side;
(8) north on Broadway to Temple St.;
(9) east on Temple St. and underneath I-93 to Temple Rd.;
(10) east on Temple Rd through the 10 Hills Neighborhood to Shore Drive;
(11) west on Shore Drive to Route 38;
(12) north on Route 38 to the Somerville/Medford line to complete the loop.

Deviations from this route occurred occasionally due to traffic detours.

A.4 Monitoring Schedule

Three intensive campaigns were conducted in different seasons: Summer (June-July) 2018, Fall (September-November) 2018 and Winter (January-February) 2019. During each campaign monitoring was performed on the days of week and hours expected to have a high flow of traffic to and from Encore Casino. These were identified as late afternoon to evening (1600-2000 hours) on Thursday and Friday and late morning to midday (1100-1500 hours) on Saturdays and Sundays. According to the Final Environmental Impact Report put forth by the Casino, in excess of 20,000 vehicle trips are anticipated on both Friday and Saturday (each day) to convey visitors to and from the casino. Depending on traffic it took between 45 minutes to 1 hour for the TAPL to complete a single circuit of the monitoring route; a total of two to seven circuits were performed on each day of monitoring. Days and times of monitoring are summarized in Table 6.

Air quality monitoring was conducted on 14 days during the summer 2018 campaign, 11 days during the fall 2018 campaign, and 15 days during the winter 2019 campaign (Table 6). These 40 days included 13 Thursdays, 12 Fridays, nine Saturdays, five Sundays, and one Tuesday. In total 191 loops were driven around the monitoring route: 72 in summer, 53 in fall and 66 in winter.

Table 6: Mobile monitoring dates and times

Campaign	**Date**	**Start Time**	**End Time**	**Number of loops**
Summer 2018	Th, 6/14/2018	3:59:51 PM	8:26:52 PM	6
Summer 2018	F, 6/15/2018	3:56:40 PM	9:04:26 PM	7
Summer 2018	Sa, 6/16/2018	1:42:06 PM	4:14:52 PM	3
Summer 2018	Tu, 6/19/2018	2:25:27 PM	4:28:14 PM	3
Summer 2018	Th, 6/21/2018	3:54:04 PM	9:17:59 PM	7
Summer 2018	F, 6/22/2018	3:52:23 PM	8:57:40 PM	7
Summer 2018	Sa, 6/23/2018	11:46:08 AM	3:14:56 PM	5
Summer 2018	Su, 6/24/2018	12:18:02 PM	2:16:31 PM	3
Summer 2018	Th, 6/28/2018	4:42:47 PM	6:44:59 PM	3
Summer 2018	F, 6/29/2018	3:56:08 PM	7:46:24 PM	5
Summer 2018	Th, 7/12/2018	5:26:17 PM	9:12:28 PM	5
Summer 2018	F, 7/13/2018	3:49:58 PM	8:51:31 PM	7
Summer 2018	Sa, 7/14/2018	11:05:15 AM	2:30:38 PM	5
Summer 2018	Th, 7/19/2018	4:00:19 PM	8:35:57 PM	6
Subtotal	*14*			*72*
Fall 2018	Th, 9/13/2018	4:39:23 PM	8:26:33 PM	5
Fall 2018	Sa, 9/15/2018	10:38:11 AM	2:03:31 PM	5
Fall 2018	F, 10/19/2018	5:03:15 PM	8:39:26 PM	5
Fall 2018	Sa, 10/20/2018	11:07:13 AM	1:43:22 PM	3
Fall 2018	Th, 10/25/2018	4:10:07 PM	8:21:14 PM	6
Fall 2018	Su, 10/28/2018	10:48:34 AM	1:06:57 PM	4
Fall 2018	Th, 11/1/2018	4:10:03 PM	8:51:30 PM	7
Fall 2018	Th, 11/8/2018	4:16:27 PM	6:51:22 PM	4
Fall 2018	F, 11/9/2018	4:04:28 PM	6:50:08 PM	4
Fall 2018	Th, 11/15/2018	4:18:46 PM	7:05:09 PM	4
Fall 2018	F, 11/16/2018	4:17:00 PM	8:36:05 PM	6
Subtotal	*11*			*53*
Winter 2018-19	Th, 1/17/2019	5:42:18 PM	7:15:48 PM	2
Winter 2018-19	F, 1/18/2019	4:31:58 PM	8:01:30 PM	4
Winter 2018-19	Sa, 1/19/2019	10:36:38 AM	1:19:57 PM	4
Winter 2018-19	F, 1/25/2019	3:50:56 PM	9:01:50 PM	7
Winter 2018-19	Sa, 1/26/2019	10:33:45 AM	1:44:48 PM	5
Winter 2018-19	Su, 1/27/2019	10:44:32 AM	1:51:22 PM	5
Winter 2018-19	Th, 1/31/2019	4:18:45 PM	5:41:10 PM	2
Winter 2018-19	F, 2/1/2019	4:33:00 PM	9:14:33 PM	6
Winter 2018-19	Sa, 2/2/2019	10:37:23 AM	12:49:20 PM	3
Winter 2018-19	Su, 2/3/2019	10:35:15 AM	1:55:54 PM	5
Winter 2018-19	Th, 2/7/2019	4:31:11 PM	5:39:05 PM	2
Winter 2018-19	F, 2/8/2019	4:08:50 PM	8:48:50 PM	6
Winter 2018-19	Sa, 2/9/2019	10:28:13 AM	12:28:48 PM	3
Winter 2018-19	Su, 2/10/2019	10:22:16 AM	2:05:01 PM	6
Winter 2018-19	F, 2/22/2019	4:23:07 PM	8:06:55 PM	6
Subtotal	*15*			*66*
Total	**40**			***191***

A.5 Air Quality Data Analysis

Air pollutant data was processed in the following manner. First, following each day of monitoring, data were downloaded from the various instruments and compiled in an MS-Excel spreadsheet. Second, data for individual pollutants went through quality assurance checks where data flagged automatically by instruments was excluded and time series were plotted and visually examined to ensure that values reported were within the expected range on roadways. Third, data from all instruments was pooled and matched to location by 1-second-interval GPS readings. Fourth, we adjusted for known time lags (i.e., time between when air arrives in the inlet line and the response of the monitor) and checked that pollutant concentration spikes were lining-up across instruments. After these steps were performed, the processed and lag-adjusted data was then converted to a database (one database per seasonal campaign), integrated with hourly meteorological data (see next section), and imported into MATLAB (2018a) for statistical analysis. For mapping, air quality measurements were integrated in 50-m x 50-m grid cells. Over 90% of the air quality data collected during the three campaigns satisfied our quality assurance metrics and were used in the analysis.

On-road mobile measurements reflect the local background and on-road emissions from local traffic. To quantify local traffic contributions to the air pollutant concentrations we controlled for the day-to-day and seasonal variation in local background. We estimated the local background as the 5th percentile of on-road measurements (similar to several previous mobile monitoring studies) per road class per lap of the monitoring route. The local traffic contribution component of the total on-road measurement was quantified as the difference of the mean and median on-road concentration (per road class per lap) from the estimated background.

A.6 Meteorological Data Acquisition

Automated Surface Observing Systems (ASOS; https://www.weather.gov/asos/) meteorological data was obtained from the National Weather Service station at Logan International Airport, Boston (KBOS, Latitude: 42°21'47"N (42.362944), Longitude: 71°00'23"W (-71.006388), Elevation: 19 ft. (6 m)). Two data streams were acquired: ASOS 6405 (wind speed, direction and character) and ASOS 6406 (temperature). This data was obtained at one-minute resolution and was aggregated to obtain hourly values. Wind data was processed through AERMINUTE (https://www.epa.gov/scram/meteorological-processors-and-accessory-programs).

B. Traffic Volume Estimation

B.1 Traffic-Related Data

We obtained anonymous Location-Based Service (LBS) mobile phone data in high spatial resolution (~10 to 100 meters) for one million mobile phone users in the Boston region (20% of the total population) for summer (June-July 2018), fall (October-November 2018), and winter months (January-February 2019). We purchased this data from a technology company (through a non-disclosure agreement) that collects locational information from anonymous users who have agreed to share their location information. We used the data to estimate traffic speed and traffic volume by time of day and day of the week for each two-month period for specific road segments within the study area. To assess the accuracy of our estimates, we obtained hourly estimated traffic speed for specific road segments in the study area for 2015 (originally estimated from vehicle-level GPS data by INRIX) from the Boston MPO (i.e., CTPS). Although the INRIX dataset was not from the same year as the LBS data, it was the most recent data set purchased by CTPS and shared with us to compare the spatial and temporal distribution of traffic condition by hour, day, month and season in the Boston region.

B.2 Traffic Data Analysis

B.2.1 Travel Mode Detection

To extract traffic volume and speed information, we first estimated the travel modes (walking, biking, driving) of each mobile phone user in the LBS dataset for each segment of their trips during the six-month period. Each device-specific entry in the dataset contained a time stamp (in hours/minutes/seconds) as well as latitude and longitude every time a mobile-phone application was in active or passive use (i.e., every few seconds). We applied the following algorithms to estimate the travel mode of each user's travel behavior.

(1) Extracting trip segments. We applied an agglomerative clustering algorithm - described in Jiang et al. (2013) - to detect stay locations and pass-by locations from the LBS data, and we then generated a trip segment between each pair of consecutive stay locations for each user during the six-month study period.

(2) Estimating mobility features. Next, we estimated mobility features of the devices, including average trip segment speed, top three maximum travel speeds, variance of the travel speed, and the frequency of stops (Zheng et al., 2008). The travel speeds were calculated based on Euclidean

(straight-line) distance since the time interval between two consecutive points of a trip segment were typically short enough (usually a few seconds).

(3) Clustering and assigning travel modes. We applied spectral clustering, an unsupervised learning method[21], to cluster the mobility features for each user. In doing so we obtained clusters of three travel modes, including walking (with an average speed around 5 km/hour), biking (with average speed around 15 km/hour), and automobile (in three sub-clusters with average speeds around 25 km/hour, 40 km/hour, and 55 km/hour). We then labeled the trip segments in the database with each corresponding travel modes.

B.2.2 Estimating Automobile Traffic Speed

To estimate traffic speed at the road segment level we performed the steps below. We also compared traffic speed estimates based on LBS mobile phone data with the INRIX traffic speed estimates at the road segment level.

(1) We first created a 10-meter x 10-meter fishnet for the Boston region using Python library GeoPandas[22] and data layers obtained from MassGIS (2018)[23]. After creating the fishnet, we overlapped the mobile phone data with the fishnet so that we could calculate the average travel speed for the extracted travel points (by automobiles) falling inside the grids.

(2) We then mapped the estimated automobile travel speed from the grid cells to road segments in GIS. After we obtained the result of the aggregated speed of automobiles in each grid cell, we overlaid the road segments on the fishnet. We then estimated the travel speed (i.e., the congested travel speed) by road segment, and compared our estimated travel speed data with the INRIX data for the same hour of day at the road-segment level. The correlation between our estimates of traffic speed with INRIX estimates was very high (Pearson correlation, r, was ~0.85), although the estimates were three years apart.

B.2.3 Estimating Traffic Volume

After estimating the hourly traffic speed for each road segment, we applied the volume-delay function employed by the CTPS regional model to estimate hourly traffic volume for the study area. The volume-

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[21] https://scikit-learn.org/stable/modules/generated/sklearn.cluster.SpectralClustering.html

[22] http://geopandas.org/

[23] Data Source: https://docs.digital.mass.gov/dataset/massgis-data-massachusetts-department-transportation-massdot-roads

delay function (also referred to as the Bureau of Public Roads (BPR) function) has been widely used and validated by transportation engineers[24] (NASEM, 2016). It takes the following form:

$$\text{Congested Speed} = \text{Free-Flow Speed} / (1+0.83*[\text{Volume}/\text{Capacity}]^{b})$$

Based on CTPS calibration for the Boston region, *b* = 5.5 for expressways and *b* = 2.7 for all other roadways (CTPS, 2017[25]). With this BPR function, we estimated hourly traffic volume for roads in the study area as follows:

$$\text{Volume} = \text{Capacity} * (1/0.83 *[\text{Free-Flow Speed}/\text{Congested Speed} -1])^{1/b}$$

For each road segment, we obtained data for road capacity and free-flow speed (which is strongly correlated with posted speed limits) from the MassGIS open data portal, and we estimated congested travel speed from the LBS mobile phone data as described above.

For each season, we estimated traffic volume for peak hours (4 pm to 7 pm) and non-peak hours (7 pm to 9 pm) for average Thursdays and Fridays, and hourly traffic volume for peak hours (10 am to 2 pm) for average Saturdays and Sundays.

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[24] National Academies of Sciences, Engineering, and Medicine 2016. Planning and Preliminary Engineering Applications Guide to the Highway Capacity Manual. Washington, DC: The National Academies Press. https://doi.org/10.17226/23632.

[25] CTPS, 2017, Methodology and Assumptions of Central Transportation Planning Staff Regional Travel Demand Modeling,https://www.cambridgema.gov/CDD/Projects/Transportation/~/media/A0E1E71498474FC490540CBB6A2EDD66.ashx (p37)

Table 7: Summary of air quality, wind speed and air temperature measurements stratified by wind direction for each seasonal campaign.

Season[1]	**Wind**[2]		**Speed**[3]	**PNC**	**CO_2**	**NO**	**BC**[4]	**$PM_{2.5}$**[5]	**WS**[5]	**Temp**
			miles/h	*number/cm³*	*ppm*	*ppb*	*ng/m³*	*mg/m³*	*knots*	*F*
Summer	N	*Avg±Std*	12 ± 12	13300 ± 85900	-	16 ± 17	657 ± 931	-	5.3 ± 1.6	80.8 ± 4.9
		Median	9	7500	-	9	392	-	5.4	82
	E	*Avg±Std*	13 ± 12	33600 ± 44100	538 ± 272	15 ± 23	1060 ± 1591	-	5.2 ± 1.9	69.8 ± 6
		Median	12	22600	441	9	837	-	5.2	69
	S	*Avg±Std*	13 ± 12	21300 ± 77500	574 ± 329	15 ± 20	991 ± 804	-	3.9 ± 1.1	67.9 ± 4.5
		Median	13	12700	446	9	838	-	4.4	68
	W	*Avg±Std*	11 ± 12	9000 ± 22600	465 ± 127	17 ± 22	1021 ± 4640	-	6.2 ± 1.2	74.4 ± 6.5
		Median	8	5200	416	9	418	-	6.4	71
	All	*Avg±Std*	13 ± 12	27200 ± 56400	547 ± 4552	15 ± 22	1008 ± 2092	-	5.1 ± 1.8	71 ± 6.7
		Median	11	14800	438	9	736	-	4.8	69
Fall	N	*Avg±Std*	14 ± 12	23500 ± 41700	466 ± 56	24 ± 37	1450 ± 4859	0.020 ± 0.009	4.3 ± 1.2	44.5 ± 8.1
		Median	13	17100	452	11	954	0.017	4.2	44
	E	*Avg±Std*	13 ± 13	22400 ± 34900	454 ± 52	21 ± 25	1615 ± 1844	0.028 ± 0.016	3.7 ± 2.3	59.2 ± 11.5
		Median	12	17300	440	14	1014	0.021	2.7	68
	S	*Avg±Std*	14 ± 12	32100 ± 55300	481 ± 62	19 ± 28	1343 ± 1001	0.016 ± 0.004	5.8 ± 2	59.9 ± 5.4
		Median	13	22500	466	9	1051	0.016	7.3	57
	W	*Avg±Std*	14 ± 12	21900 ± 44100	460 ± 55	16 ± 21	882 ± 798	0.014 ± 0.003	5.6 ± 1	48.3 ± 9.2
		Median	15	15200	447	9	658	0.014	5.4	49
	All	*Avg±Std*	14 ± 13	23700 ± 42900	462 ± 56	19 ± 27	1276 ± 2473	0.02 ± 0.011	4.8 ± 1.9	52.4 ± 11.3
		Median	13	17500	448	11	905	0.016	5	53
Winter	N	*Avg±Std*	15 ± 12	31300 ± 95100	536 ± 87	16 ± 17	957 ± 1019	0.022 ± 0.006	4.1 ± 0.7	32.1 ± 1.6
		Median	15	17100	520	9	671	0.023	4.2	32
	E	*Avg±Std*	14 ± 12	49700 ± 61800	466 ± 55	16 ± 33	715 ± 183	0.031 ± 0.003	2.4 ± 0.7	32.2 ± 3.7
		Median	15	44000	449	9	710	0.031	2.1	34
	S	*Avg±Std*	15 ± 12	19000 ± 23900	470 ± 66	10 ± 13	443 ± 347	0.018 ± 0.004	5.9 ± 2.4	39.9 ± 5.6
		Median	16	14700	446	6	365	0.016	6.1	43
	W	*Avg±Std*	13 ± 12	27800 ± 66100	467 ± 61	12 ± 15	817 ± 602	0.02 ± 0.008	5.1 ± 1.1	32.4 ± 8.9
		Median	13	21700	447	8	678	0.019	5.1	36
	All	*Avg±Std*	14 ± 12	25800 ± 58700	463 ± 61	13 ± 19	611 ± 584	0.02 ± 0.008	4.7 ± 1.7	34.4 ± 7.7
		Median	14	18600	442	7	460	0.019	4.6	35

[1] Seasons: summer = June and July 2018, fall = September to November 2018, winter = January and February 2019. See Table 6.

[2] N = 0±45; E = 90±45; S = 180±45; W =270±45.

[3] Average speed of TAPL including time spent at traffic lights, stop signs, and driving in congested traffic.

[4] 880 nm wavelength channel

[5] Wind speed. 1 knot = 1.15 miles/h

Table 8: Summary of air quality, wind speed and air temperature measurements stratified by day of the week for each seasonal campaign.

Season[1]	**Day of Week**		**Speed**[2]	**PNC**	**CO$_2$**	**NO**	**BC**[3]	**PM$_{2.5}$**	**WS**[4]	**Temp**
			miles/h	*number/cm^3*	*ppm*	*ppb*	*ng/m^3*	*mg/m^3*	*knots*	*F*
Summer	Tuesday	*Avg±Std*	11 ± 11	15900 ± 117300	476 ± 141	15 ± 15	624 ± 940	-	6.7 ± 0.2	82.1 ± 0.3
		Median	6.5	8000	419	9	350	-	6.5	82
	Thursday	*Avg±Std*	12 ± 12	32100 ± 61200	578 ± 6722	14 ± 18	1232 ± 2778	-	4.9 ± 1.6	69.9 ± 2.8
		Median	10.5	23000	445	8	917	-	4.8	69
	Friday	*Avg±Std*	13 ± 12	29800 ± 49600	575 ± 314	17 ± 27	971 ± 884	-	5.1 ± 2.3	69.8 ± 8
		Median	12	15800	446	9	823	-	4.4	69
	Saturday	*Avg±Std*	14 ± 12	16500 ± 24500	445 ± 83	14 ± 21	737 ± 2346	-	5.3 ± 0.7	72.3 ± 8.4
		Median	13	10100	417	7	489	-	5.3	74
	Sunday	*Avg±Std*	14 ± 12	12800 ± 31800	481 ± 103	14 ± 20	862 ± 1316	-	3.8 ± 1.2	72.9 ± 1.4
		Median	12	5700	440	7	619	-	4.2	72
Fall	Thursday	*Avg±Std*	13 ± 13	24600 ± 43900	461 ± 54	22 ± 33	1226 ± 3242	0.019 ± 0.007	4.1 ± 1.6	50.7 ± 11.2
		Median	12	17300	447	11	888	0.017	3.6	53
	Friday	*Avg±Std*	14 ± 12	28100 ± 53500	470 ± 58	15 ± 20	1139 ± 1294	0.015 ± 0.004	6.5 ± 1.2	47.3 ± 8
		Median	13	20900	455	9	956	0.014	6.8	50
	Saturday	*Avg±Std*	14 ± 13	17500 ± 18600	454 ± 58	22 ± 20	1953 ± 1368	0.035 ± 0.018	4.2 ± 2.4	67.5 ± 3.2
		Median	14	14900	437	17	1955	0.047	2.2	68
	Sunday	*Avg±Std*	16 ± 13	13400 ± 18000	460 ± 52	15 ± 23	583 ± 765	0.011 ± 0.002	4.6 ± 0.7	49.8 ± 0.9
		Median	17	8400	447	8	392	0.011	4.6	49
Winter	Thursday	*Avg±Std*	14 ± 12	35200 ± 53900	471 ± 56	20 ± 38	-	0.019 ± 0.003	4.8 ± 2.4	27.2 ± 9.5
		Median	13	24100	455	10	-	0.018	4.2	27
	Friday	*Avg±Std*	13 ± 12	24300 ± 37600	467 ± 62	12 ± 14	689 ± 551	0.02 ± 0.007	5.1 ± 0.9	36.4 ± 8.5
		Median	13	19600	446	8	540	0.019	5.1	39
	Saturday	*Avg±Std*	14 ± 12	24100 ± 94400	456 ± 68	12 ± 17	645 ± 695	0.018 ± 0.011	3.9 ± 0.8	30.8 ± 2.4
		Median	15	14500	429	7	482	0.019	3.6	31
	Sunday	*Avg±Std*	15 ± 13	27900 ± 44100	458 ± 54	11 ± 13	422 ± 448	0.02 ± 0.008	4.7 ± 2.8	37.1 ± 4.7
		Median	16	19000	439	7	313	0.016	2.9	35

[1] Seasons: summer = June and July 2018, fall = September to November 2018, winter = January and February 2019. See Table 6.

[2] Average speed of TAPL including time spent at traffic lights, stop signs, and driving in congested traffic.

[3] 880 nm wavelength channel.

[4] Wind speed. 1 knot = 1.15 miles/h

Table 9: Summary of air quality, wind speed and air temperature measurements stratified by hour of the day and day of the week for each seasonal campaign.

Season[1]	**Day**	**Hour[2]**		**Speed[3]**	**PNC**	**CO$_2$**	**NO**	**BC[4]**	**PM$_{2.5}$**	**WS[5]**	**Temp**
				miles/h	*number/cm^3*	*ppm*	*ppb*	*ng/m^3*	*mg/m^3*	*knots*	*F*
Summer	Tuesday	14	*Avg±Std*	10 ± 11	16300 ± 19300	410 ± 40	13 ± 11	769 ± 906	-	6.5 ± 0	82.1 ± 0
			Median	2	10100	399	8	423	-	6.5	82
		15	*Avg±Std*	11 ± 12	18600 ± 179100	473 ± 134	16 ± 17	669 ± 1178	-	6.9 ± 0	82.3 ± 0
			Median	6.5	7400	418	9	293	-	6.9	82
		16	*Avg±Std*	12 ± 10	10600 ± 17900	565 ± 181	17 ± 17	364 ± 174	-	6.4 ± 0	81.6 ± 0
			Median	10.5	7300	498	10	326	-	6.4	82
	Thursday	15	*Avg±Std*	12 ± 14	17100 ± 8200	422 ± 55	13 ± 11	718 ± 304	-	6.8 ± 0.8	73.3 ± 1.9
			Median	4.5	17800	400	7	644	-	6.5	74
		16	*Avg±Std*	14 ± 13	18300 ± 131600	546 ± 215	18 ± 28	2012 ± 6548	-	6 ± 1	72.4 ± 2.3
			Median	12	8400	461	10	716	-	6.5	72
		17	*Avg±Std*	11 ± 11	30800 ± 43700	521 ± 242	12 ± 12	879 ± 701	-	5.7 ± 1.1	71.5 ± 2.3
			Median	6	10000	437	9	777	-	5.8	71
		18	*Avg±Std*	12 ± 12	45100 ± 35900	504 ± 178	12 ± 12	1049 ± 623	-	5.3 ± 1	70 ± 2.3
			Median	10.5	48900	438	8	967	-	5.3	70
		19	*Avg±Std*	13 ± 12	36700 ± 26500	553 ± 305	14 ± 21	1256 ± 922	-	4.6 ± 1.3	68.1 ± 1.4
			Median	13	33100	443	8	1101	-	4.4	69
		20	*Avg±Std*	13 ± 12	30100 ± 20100	646 ± 456	11 ± 13	1189 ± 770	-	3.1 ± 1.3	67.3 ± 1.1
			Median	11.25	27500	451	8	1040	-	2.7	67
		21	*Avg±Std*	13 ± 10	22300 ± 12200	-	13 ± 19	1278 ± 842	-	1.9 ± 0.3	66.3 ± 0.9
			Median	14	20900	-	7	1082	-	1.7	66
	Friday	15	*Avg±Std*	14 ± 13	29400 ± 32500	525 ± 181	13 ± 11	852 ± 633	-	5.9 ± 2.8	68.6 ± 7.4
			Median	13	15300	437	9	587	-	4.7	69
		16	*Avg±Std*	12 ± 12	27400 ± 54200	545 ± 259	17 ± 25	1128 ± 1488	-	6.2 ± 2.7	70.5 ± 7.1
			Median	11	15500	440	9	795	-	6.6	69
		17	*Avg±Std*	12 ± 12	33900 ± 76100	531 ± 250	15 ± 18	868 ± 530	-	5.6 ± 2.6	71.4 ± 8.2
			Median	9	18100	439	9	760	-	6.4	69
		18	*Avg±Std*	13 ± 12	28700 ± 31000	543 ± 273	20 ± 39	831 ± 460	-	4.8 ± 2.3	71.4 ± 9.5
			Median	12	17400	437	9	782	-	4.4	69
		19	*Avg±Std*	13 ± 12	31300 ± 43200	612 ± 377	16 ± 20	981 ± 662	-	4.9 ± 1.6	70.1 ± 9
			Median	12.5	10900	450	10	867	-	5.5	68
		20	*Avg±Std*	14 ± 11	28900 ± 25900	707 ± 417	21 ± 29	1070 ± 910	-	4.1 ± 1.1	65.7 ± 2.9
			Median	14	17500	496	10	892	-	4.7	66
		21	*Avg±Std*	10 ± 11	20400 ± 8400	-	13 ± 10	1127 ± 449	-	3.1 ± 0.3	62.9 ± 0.9
			Median	2	18200	-	9	1040	-	2.9	63

	Saturday	11	*Avg±Std*	14 ± 13	35700 ± 24100	452 ± 91	15 ± 21	1783 ± 6825	-	6.2 ± 0.5	71.7 ± 4.5
			Median	14	33400	417	8	735	-	6.5	74
		12	*Avg±Std*	13 ± 13	15400 ± 27000	471 ± 113	13 ± 24	567 ± 324	-	5.1 ± 0.6	68.9 ± 5.9
			Median	10	10800	430	7	498	-	5.1	69
		13	*Avg±Std*	14 ± 12	13600 ± 11800	437 ± 57	13 ± 15	674 ± 912	-	5.6 ± 0.3	71.4 ± 8.6
			Median	13	11000	419	8	485	-	5.4	74
		14	*Avg±Std*	14 ± 12	15200 ± 31300	420 ± 37	17 ± 24	658 ± 769	-	5.4 ± 0.7	72.2 ± 9.5
			Median	14	9000	410	8	476	-	5.5	72
		15	*Avg±Std*	14 ± 12	9400 ± 19000	392 ± 13	7 ± 4	544 ± 462	-	4.4 ± 0.2	77.1 ± 8.8
			Median	14.5	5200	389	6	378	-	4.3	83
		16	*Avg±Std*	14 ± 15	9400 ± 21700	-	-	389 ± 228	-	3.8 ± 0	82.2 ± 0
			Median	14	5200	-	-	316	-	3.8	82
	Sunday	12	*Avg±Std*	13 ± 12	14100 ± 42800	426 ± 56	14 ± 24	1009 ± 2029	-	2.4 ± 0	74.5 ± 0
			Median	11	5200	406	7	559	-	2.4	75
		13	*Avg±Std*	14 ± 13	11200 ± 12500	519 ± 112	16 ± 18	717 ± 390	-	4.2 ± 0	72.2 ± 0
			Median	12	8200	493	9	595	-	4.2	72
		14	*Avg±Std*	14 ± 11	21500 ± 2600	514 ± 104	7 ± 5	890 ± 299	-	5.8 ± 0	70.7 ± 0
			Median	16	21300	499	4	919	-	5.8	71
Fall	Thursday	16	*Avg±Std*	15 ± 13	22100 ± 31100	465 ± 55	22 ± 31	1090 ± 834	0.018 ± 0.006	4.6 ± 1.9	49.3 ± 10.5
			Median	15	14300	452	11	903	0.016	3.6	53
		17	*Avg±Std*	12 ± 13	24600 ± 50200	459 ± 54	25 ± 37	1530 ± 5771	0.018 ± 0.005	4.1 ± 1.6	50.2 ± 11.9
			Median	10	16700	446	13	801	0.016	4.2	50
		18	*Avg±Std*	13 ± 13	25900 ± 55600	462 ± 56	20 ± 29	1132 ± 1728	0.018 ± 0.01	4.1 ± 1.3	49.1 ± 10.9
			Median	12	20300	449	11	891	0.016	4.2	49
		19	*Avg±Std*	14 ± 12	26800 ± 30600	454 ± 44	20 ± 32	1150 ± 847	0.019 ± 0.005	3.7 ± 1.2	53.6 ± 11.1
			Median	13	16900	444	10	968	0.02	2.9	53
		20	*Avg±Std*	14 ± 12	22000 ± 18600	465 ± 57	17 ± 30	997 ± 591	0.023 ± 0.006	3.4 ± 1.5	54.6 ± 9.6
			Median	14	14400	446	8	927	0.026	2.7	53
	Friday	16	*Avg±Std*	14 ± 13	25100 ± 63800	448 ± 44	18 ± 27	1105 ± 2523	0.013 ± 0.004	7 ± 1.4	44.6 ± 5.9
			Median	13	16200	436	10	736	0.012	8.2	50
		17	*Avg±Std*	12 ± 12	29900 ± 56000	459 ± 57	14 ± 18	962 ± 813	0.013 ± 0.004	6.8 ± 1.1	48.4 ± 8.3
			Median	8	18700	442	8	766	0.012	7.3	50
		18	*Avg±Std*	14 ± 12	25800 ± 31900	482 ± 68	16 ± 19	1079 ± 707	0.015 ± 0.003	6 ± 0.8	47.2 ± 7.9
			Median	14	22600	462	9	972	0.014	6.5	49
		19	*Avg±Std*	13 ± 12	29800 ± 26900	484 ± 56	15 ± 20	1514 ± 1238	0.017 ± 0.003	6.1 ± 1.4	48.4 ± 8.6
			Median	13	25400	470	8	1171	0.017	7.3	56
		20	*Avg±Std*	17 ± 12	30800 ± 86900	474 ± 44	11 ± 16	1213 ± 483	0.017 ± 0.002	6.7 ± 0.8	47 ± 8.3
			Median	18	20400	467	5	1102	0.017	7.5	55

	Saturday	10	*Avg±Std*	15 ± 14	24900 ± 16300	465 ± 52	34 ± 21	3496 ± 1023	0.049 ± 0.004	1.6 ± 0	67.6 ± 0
			Median	14	21900	454	31	3475	0.049	1.6	68
		11	*Avg±Std*	14 ± 12	16000 ± 13700	460 ± 68	23 ± 20	1982 ± 1178	0.035 ± 0.017	4.6 ± 2.6	66.7 ± 2.6
			Median	14	14300	438	18	2286	0.048	2.2	69
		12	*Avg±Std*	14 ± 15	15300 ± 16800	454 ± 54	20 ± 14	1896 ± 1685	0.032 ± 0.019	4.7 ± 2.3	67.1 ± 3.3
			Median	13	12400	442	17	768	0.015	6.8	64
		13	*Avg±Std*	14 ± 12	19800 ± 24200	446 ± 51	20 ± 22	1632 ± 1005	0.034 ± 0.017	3.8 ± 2	68.6 ± 3.6
			Median	14	17300	431	13	1754	0.046	2	72
		14	*Avg±Std*	12 ± 13	12700 ± 3100	447 ± 49	17 ± 23	1745 ± 335	0.046 ± 0.002	3.2 ± 0	71.9 ± 0
			Median	2.5	11400	435	9	1547	0.047	3.2	72
	Sunday	10	*Avg±Std*	22 ± 13	21900 ± 23800	501 ± 63	33 ± 46	645 ± 322	0.009 ± 0.001	3.2 ± 0	48.3 ± 0
			Median	25	13600	496	15	504	0.009	3.2	48
		11	*Avg±Std*	15 ± 12	10400 ± 11900	448 ± 46	14 ± 18	454 ± 651	0.01 ± 0.002	5.2 ± 0	49.3 ± 0
			Median	16	7100	434	8	299	0.01	5.2	49
		12	*Avg±Std*	17 ± 13	14200 ± 19700	463 ± 51	12 ± 16	653 ± 792	0.012 ± 0.002	4.6 ± 0	50.1 ± 0
			Median	19	9000	451	7	466	0.012	4.6	50
		13	*Avg±Std*	11 ± 11	17000 ± 26400	468 ± 39	8 ± 5	921 ± 1426	0.013 ± 0.004	3 ± 0	52.8 ± 0
			Median	8	8800	464	7	330	0.012	3	53
Winter	Thursday	16	*Avg±Std*	14 ± 13	31800 ± 73700	453 ± 45	15 ± 15	-	0.019 ± 0.004	6.7 ± 0	27.1 ± 11.8
			Median	13	21600	442	8	-	0.018	6.7	17
		17	*Avg±Std*	13 ± 12	33200 ± 26000	463 ± 53	17 ± 18	-	0.019 ± 0.002	6.1 ± 2.3	27.4 ± 10.8
			Median	11	25200	445	10	-	0.019	7.6	26
		18	*Avg±Std*	14 ± 11	69800 ± 31800	487 ± 54	33 ± 73	-	-	2 ± 0	27 ± 0
			Median	14	60300	476	16	-	-	2	27
		19	*Avg±Std*	15 ± 9	-	526 ± 67	12 ± 9	-	-	4.2 ± 0	27 ± 0
			Median	17	-	521	8	-	-	4.2	27
	Friday	15	*Avg±Std*	15 ± 13	18200 ± 17500	472 ± 63	12 ± 7	536 ± 240	0.016 ± 0.002	6.7 ± 0	39.2 ± 0
			Median	12	10400	456	9	476	0.016	6.7	39
		16	*Avg±Std*	13 ± 12	19300 ± 22800	485 ± 73	16 ± 18	705 ± 653	0.017 ± 0.003	5.7 ± 1	39.8 ± 8.5
			Median	12	14600	460	9	532	0.016	6.2	41
		17	*Avg±Std*	12 ± 12	25100 ± 23400	478 ± 65	12 ± 12	801 ± 624	0.02 ± 0.007	5.2 ± 0.6	37.9 ± 9.1
			Median	10	19900	458	8	600	0.018	5.1	40
		18	*Avg±Std*	12 ± 12	23300 ± 22600	474 ± 73	11 ± 11	741 ± 506	0.019 ± 0.003	4.6 ± 0.6	38.6 ± 5.4
			Median	9	19700	446	7	661	0.019	4.7	39
		19	*Avg±Std*	15 ± 12	27900 ± 63600	456 ± 45	12 ± 14	711 ± 528	0.023 ± 0.01	4.5 ± 0.8	35.4 ± 7.7
			Median	16	22800	443	7	576	0.021	4	39
		20	*Avg±Std*	16 ± 12	22300 ± 18900	439 ± 35	9 ± 10	425 ± 246	0.021 ± 0.003	5.8 ± 0.6	30.1 ± 7.2
			Median	18	16200	432	6	372	0.021	5.4	34
		21	*Avg±Std*	16 ± 10	35300 ± 11600	448 ± 32	14 ± 16	287 ± 27	0.024 ± 0.003	5 ± 0.1	20.5 ± 4.3
			Median	18	34200	440	8	265	0.023	5	19

	Saturday	10	*Avg±Std*	14 ± 12	25400 ± 33700	445 ± 53	15 ± 26	653 ± 1024	0.017 ± 0.005	4.4 ± 0.8	28.9 ± 3.3
			Median	14	15700	425	8	443	0.019	4.3	31
		11	*Avg±Std*	15 ± 12	26700 ± 133200	451 ± 60	12 ± 16	610 ± 697	0.017 ± 0.005	3.9 ± 0.7	30.3 ± 2.1
			Median	15	15300	427	7	450	0.019	4.2	31
		12	*Avg±Std*	14 ± 12	21900 ± 76600	470 ± 85	11 ± 12	683 ± 569	0.02 ± 0.018	3.7 ± 1	31.6 ± 1.1
			Median	14	13600	431	7	518	0.02	3.5	31
		13	*Avg±Std*	14 ± 11	19300 ± 25000	452 ± 53	12 ± 15	637 ± 290	0.021 ± 0.002	3.5 ± 0.2	33 ± 1.5
			Median	16	13200	435	7	538	0.021	3.6	34
	Sunday	10	*Avg±Std*	16 ± 13	27600 ± 33400	435 ± 35	11 ± 16	538 ± 682	0.018 ± 0.007	3.3 ± 1.1	33.8 ± 2.9
			Median	17	18200	426	6	363	0.015	2.5	34
		11	*Avg±Std*	15 ± 13	31700 ± 70000	453 ± 48	12 ± 13	408 ± 348	0.019 ± 0.008	4.2 ± 2	36.6 ± 4.4
			Median	16	19400	438	7	317	0.016	6.1	34
		12	*Avg±Std*	15 ± 12	23700 ± 22000	464 ± 55	10 ± 10	414 ± 472	0.02 ± 0.009	5 ± 3.6	37.7 ± 4.9
			Median	16	17100	445	7	313	0.016	1.6	35
		13	*Avg±Std*	15 ± 12	28000 ± 21200	467 ± 64	11 ± 15	392 ± 376	0.021 ± 0.009	5.7 ± 2.9	38.7 ± 4.8
			Median	16	20000	443	6	297	0.015	2.9	36
		14	*Avg±Std*	18 ± 13	19100 ± 3500	446 ± 26	-	394 ± 211	0.013 ± 0.001	-	36 ± 0
			Median	22	18500	441	-	319	0.013	-	36

[1] Seasons: summer = June and July 2018, fall = September to November 2018, winter = January and February 2019. See Table 6.

[2] 'Hour' is defined as 00:00 to 59:59 minutes:seconds after the beginning of the hour; e.g., 14:00:00 to 14:59:59 (3600 seconds of data) is categorized as all belonging to hour 14.

[3] Average speed of TAPL including time spent at traffic lights, stop signs, and driving in congested traffic.

[4] 880 nm wavelength channel

[5] Wind speed. 1 knot = 1.15 miles/h

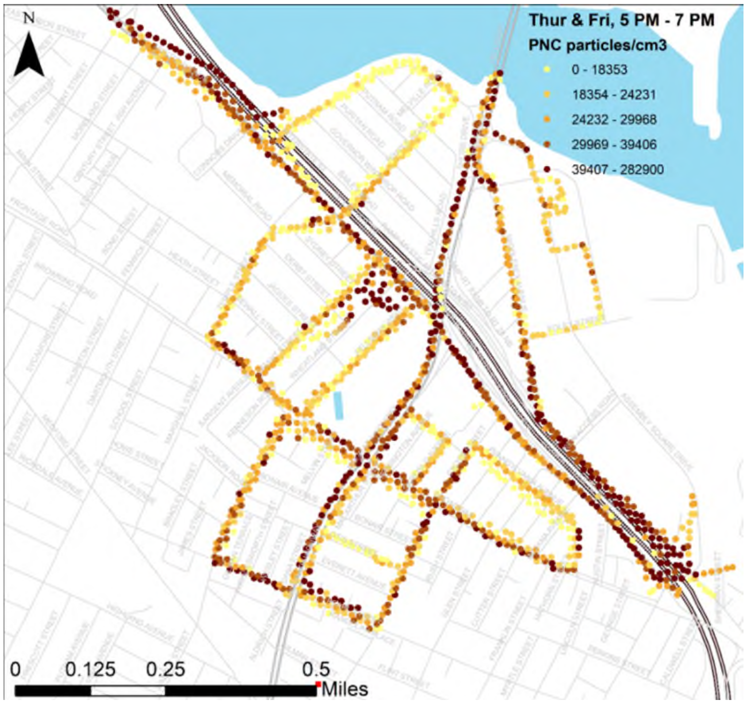

Figure 10: Spatial distribution of particle number concentration (PNC) during evening rush hour (5-7 PM) on weekdays (Th-F). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

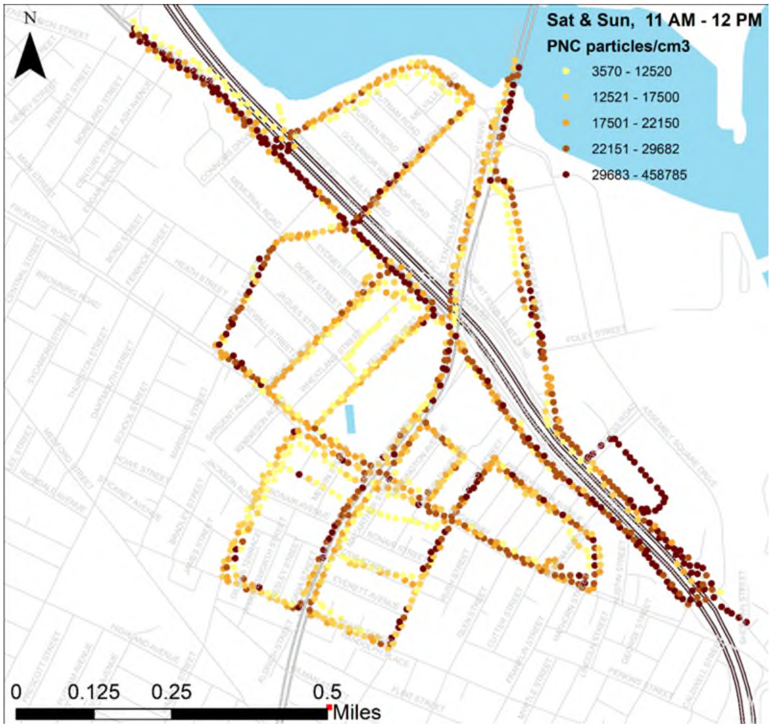

Figure 11: Spatial distribution of particle number concentration (PNC) during midday rush hours (11 AM - 12 noon) on weekends (Sa-Su). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

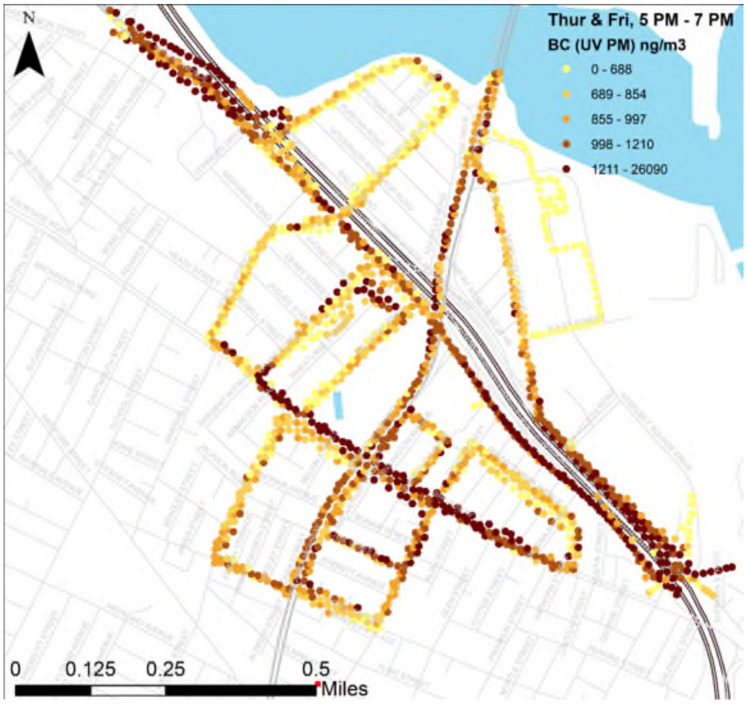

Figure 12: Spatial distribution of black carbon (BC) concentration during evening rush hour (5-7 PM) on weekdays (Th-F). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

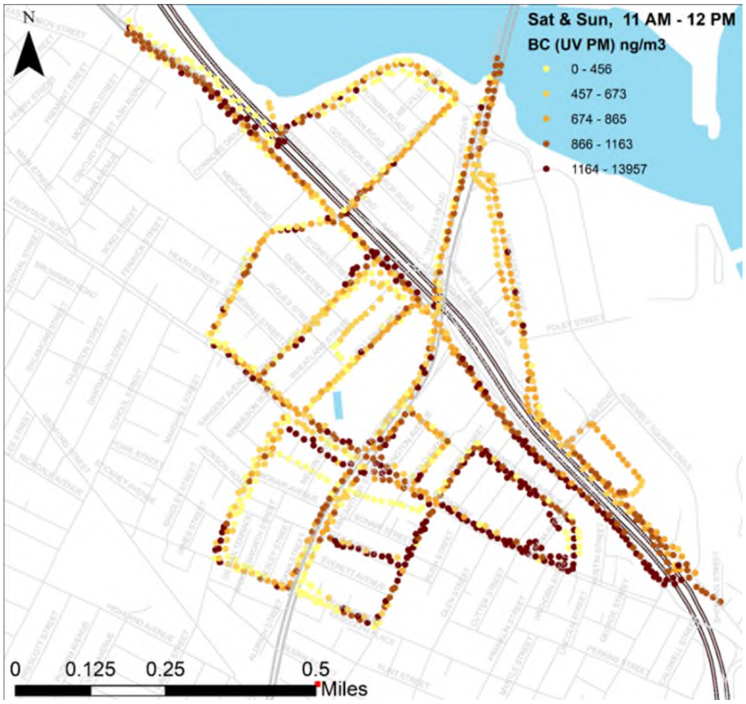

Figure 13: Spatial distribution of black carbon (BC) concentration during midday rush hours (11 AM - 12 noon) on weekends (Sa-Su). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

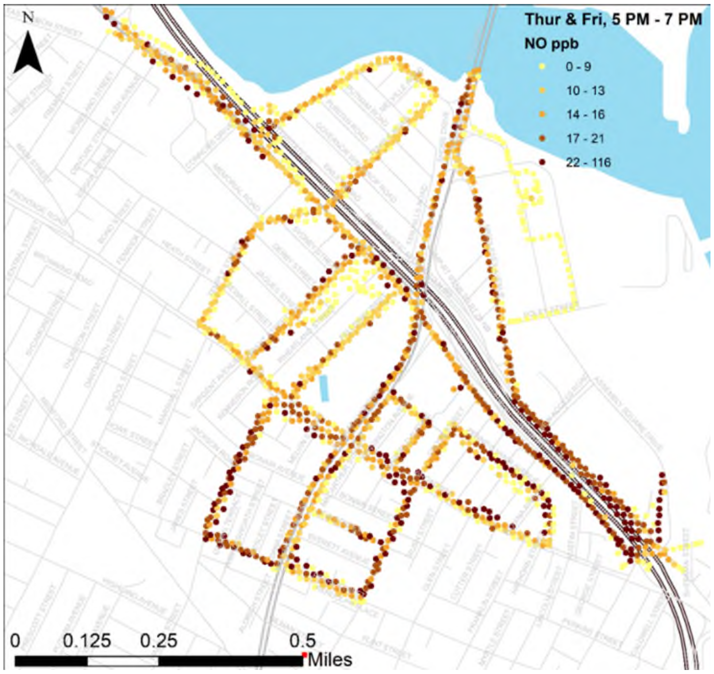

Figure 14: Spatial distribution of nitric oxide (NO) concentration during evening rush hour (5-7 PM) on weekdays (Th-F). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

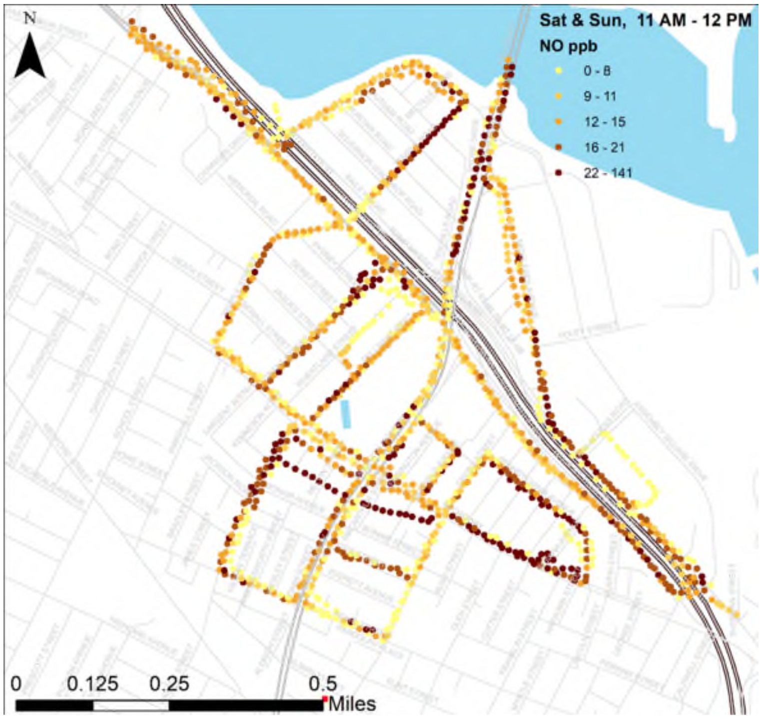

Figure 15: Spatial distribution of nitric oxide (NO) concentration during midday rush hours (11 AM - 12 noon) on weekends (Sa-Su). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

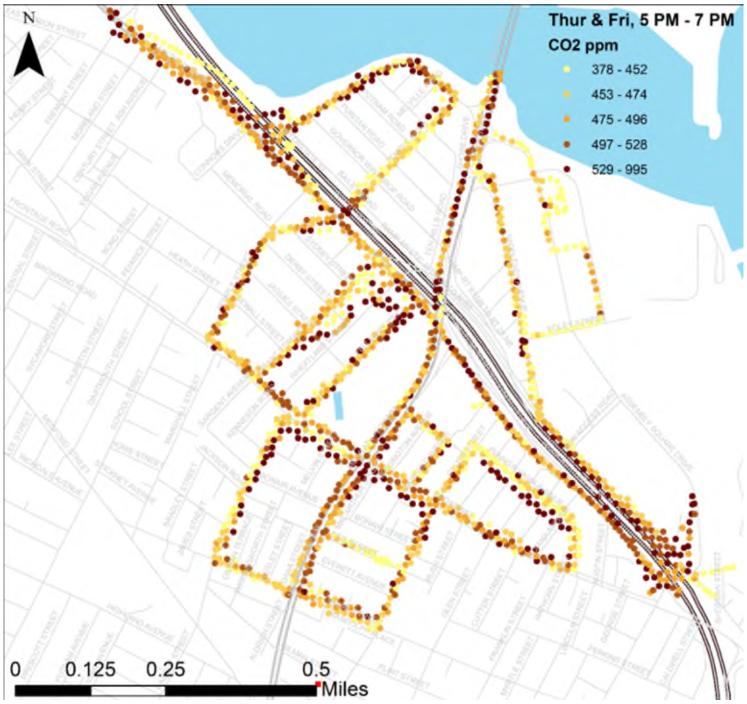

Figure 16: Spatial distribution of carbon dioxide (CO$_2$) concentration during evening rush hour (5-7 PM) on weekdays (Th-F). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

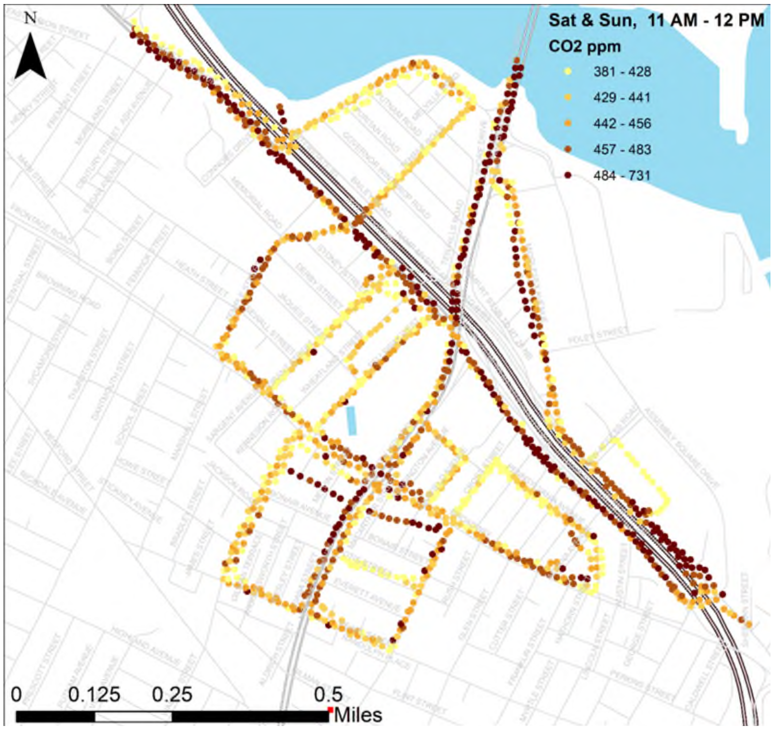

Figure 17: Spatial distribution of carbon dioxide (CO2) concentration during midday rush hours (11 AM - 12 noon) on weekends (Sa-Su). Each data point represents the average of all measurements in all three seasons within 50-m x 50-m grid cells.

Figure 18: Estimated Traffic Volume and Volume over Capacity (VoC) for PM Peak Hour (4-7PM) and Non-Peak Hour(7-9PM) on Thursdays and Fridays for All Seasons (2018, 2019)

Figure 19: Estimated Traffic Volume and Volume over Capacity (VoC) for PM Peak Hour and Non-Peak Hour on Thursdays and Fridays for Summer (June, July, 2018)

Figure 20: Estimated Traffic Volume and Volume over Capacity (VoC) for PM Peak Hour and Non-Peak Hour on Thursdays and Fridays for Fall (Oct, Nov, 2018)

Figure 21: Estimated Traffic Volume and Volume over Capacity (VoC) for PM Peak Hour and Non-Peak Hour on Thursdays and Fridays for Winter (Jan, Feb, 2019)

Figure 22: Estimated Traffic Volume and Volume over Capacity (VoC) for Non-Peak Hour on Saturdays and Sundays for Summer (June, July, 2018) and Winter (Jan, Feb, 2019).

Figure 23: Estimated Traffic Volume and Volume over Capacity (VoC) for Non-Peak Hour on Saturdays and Sundays for All Season and Fall (Oct, Nov, 2018).

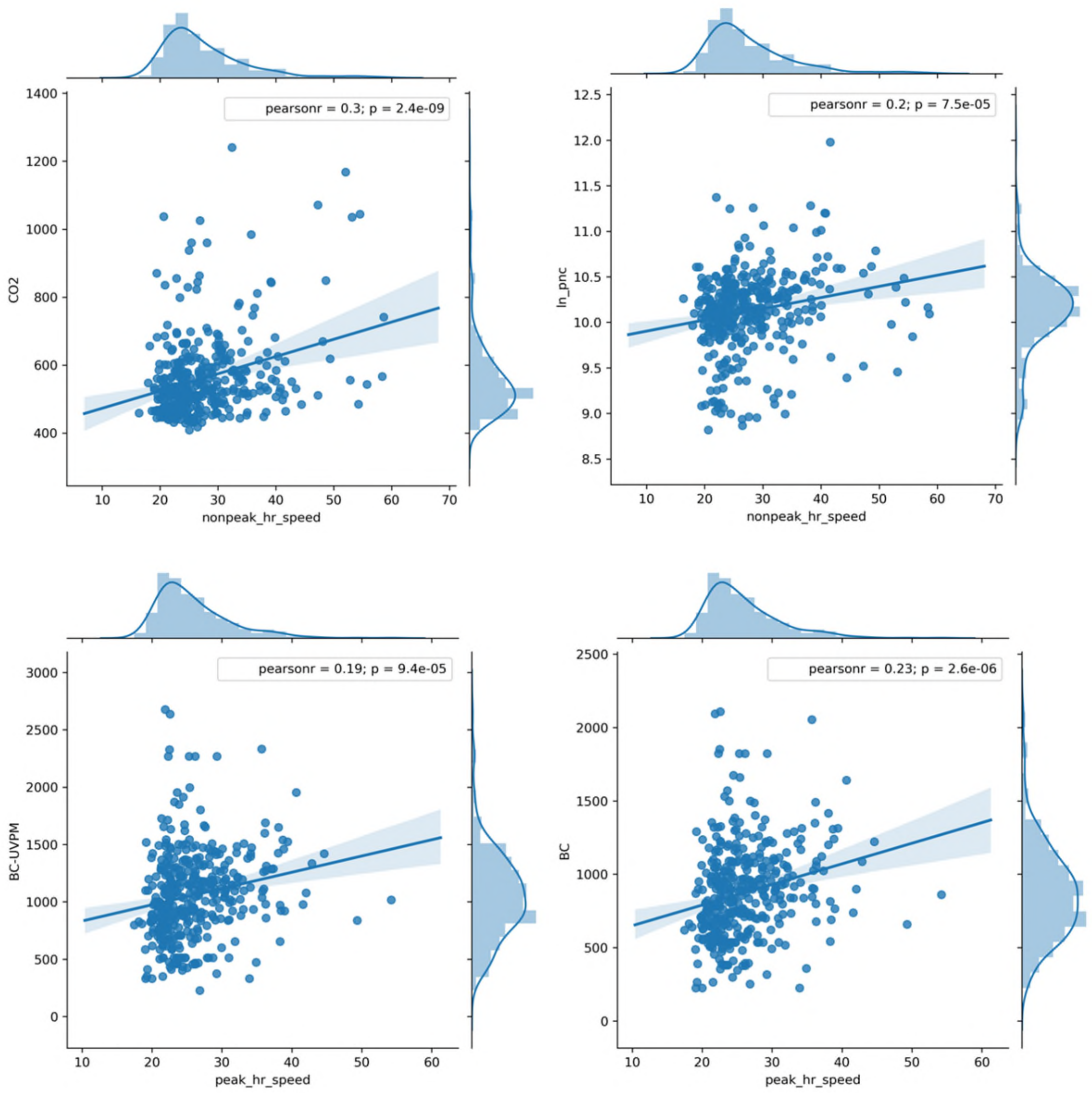

Figure 24: Relationship between Air Quality Measures and Traffic Speed during PM Peak Hours (4-7 PM) and Non-Peak Hours (after 7PM) on Weekdays (Th-F) for all Seasons (2018, 2019). Note: Plots are only shown for those with Pearson Correlation r>0.15.

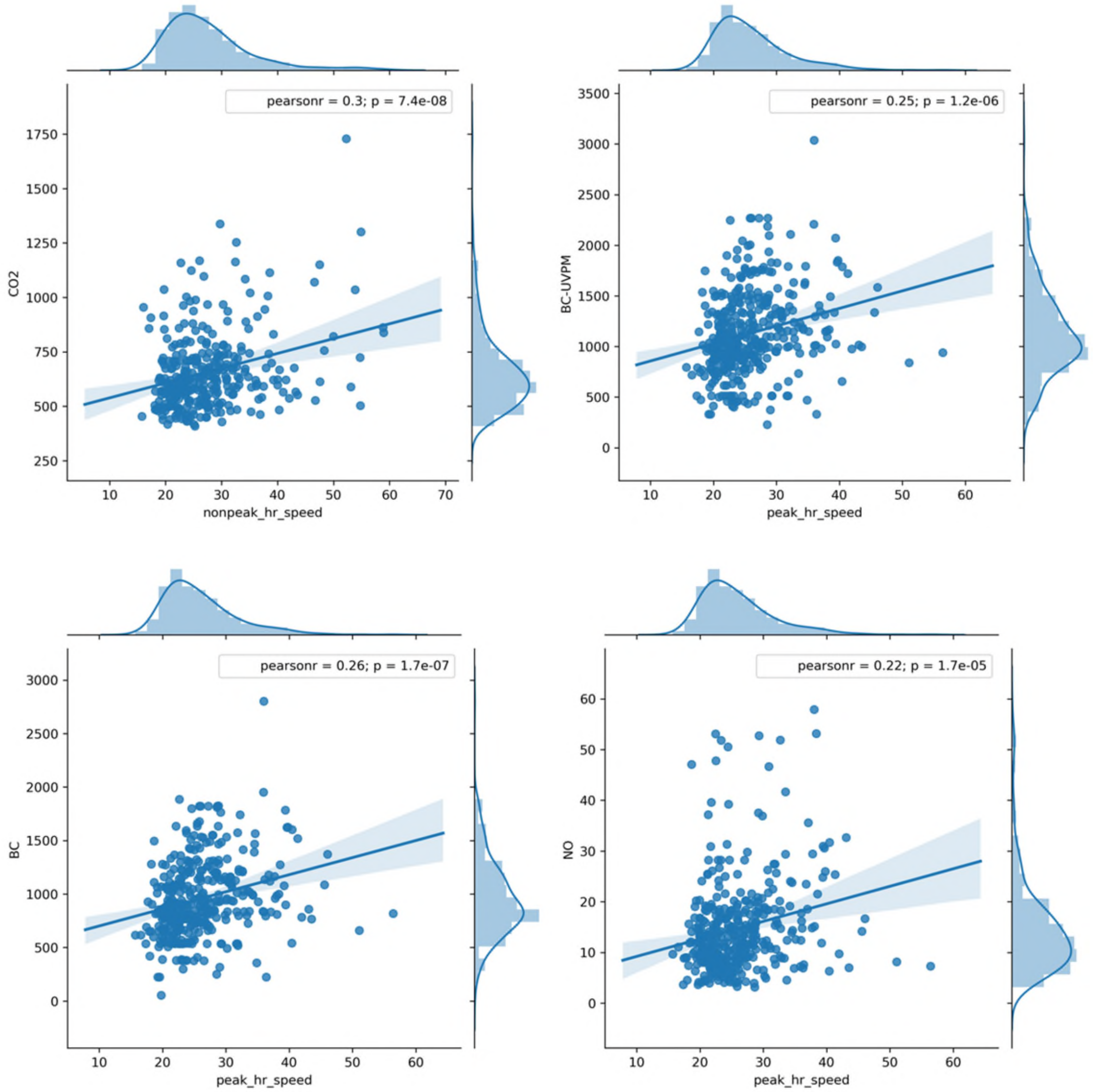

Figure 25*:* Relationship between Air Quality Measures and Traffic Speed during PM Peak Hours (4-7 PM) and Non-Peak Hours (after 7PM) on Weekdays (Th-F) for Summer (June, July, 2018). Note: Plots are only shown for those with Pearson Correlation r>0.15.

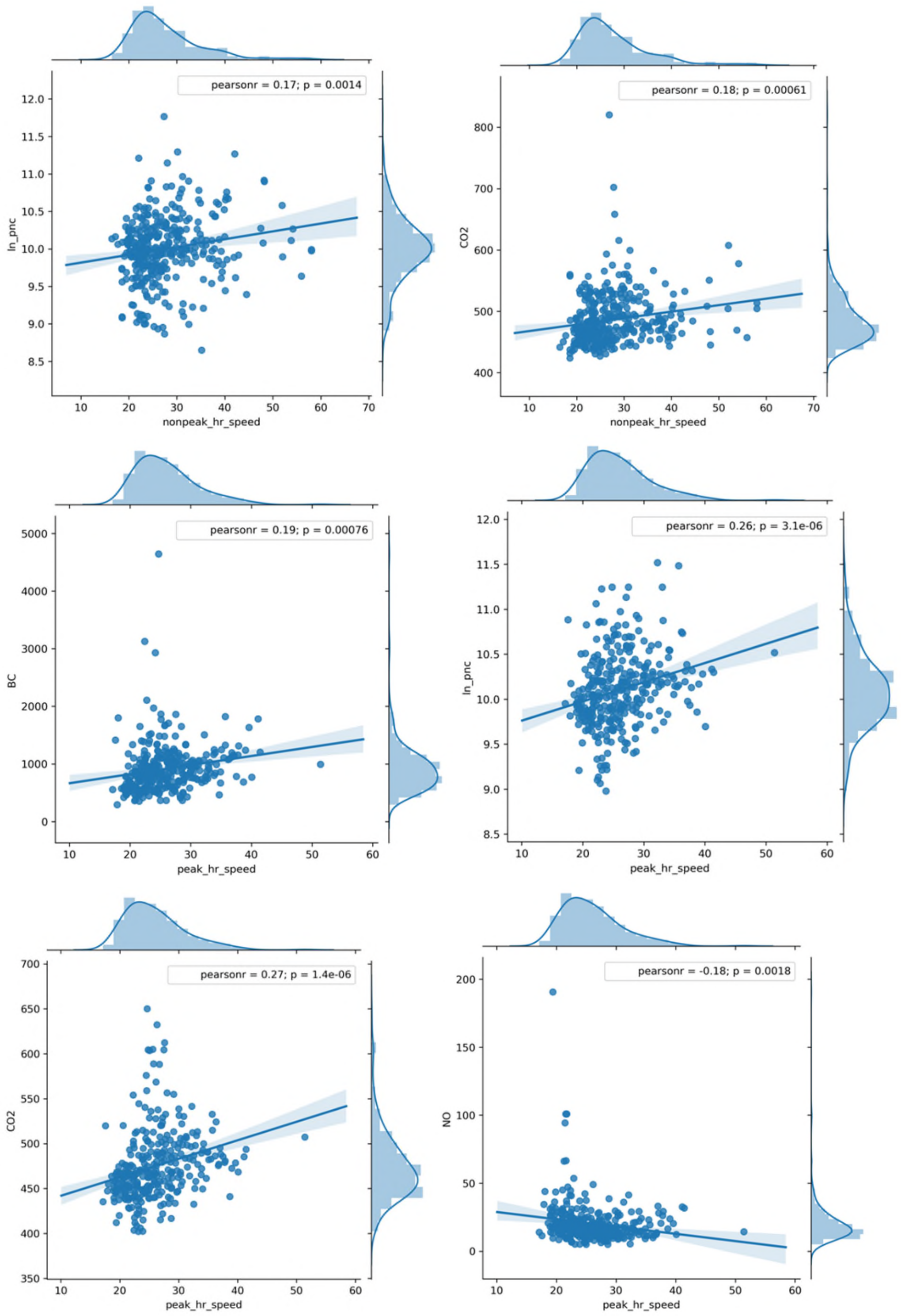

Figure 26*:* **Relationship between Air Quality Measures and Traffic Speed during PM Peak Hours (4-7 PM) and Non-Peak Hours (after 7PM) on Weekdays (Th-F) for Fall (Oct, Nov. 2018). Note: Plots are only shown for those with Pearson Correlation r>0.15.**

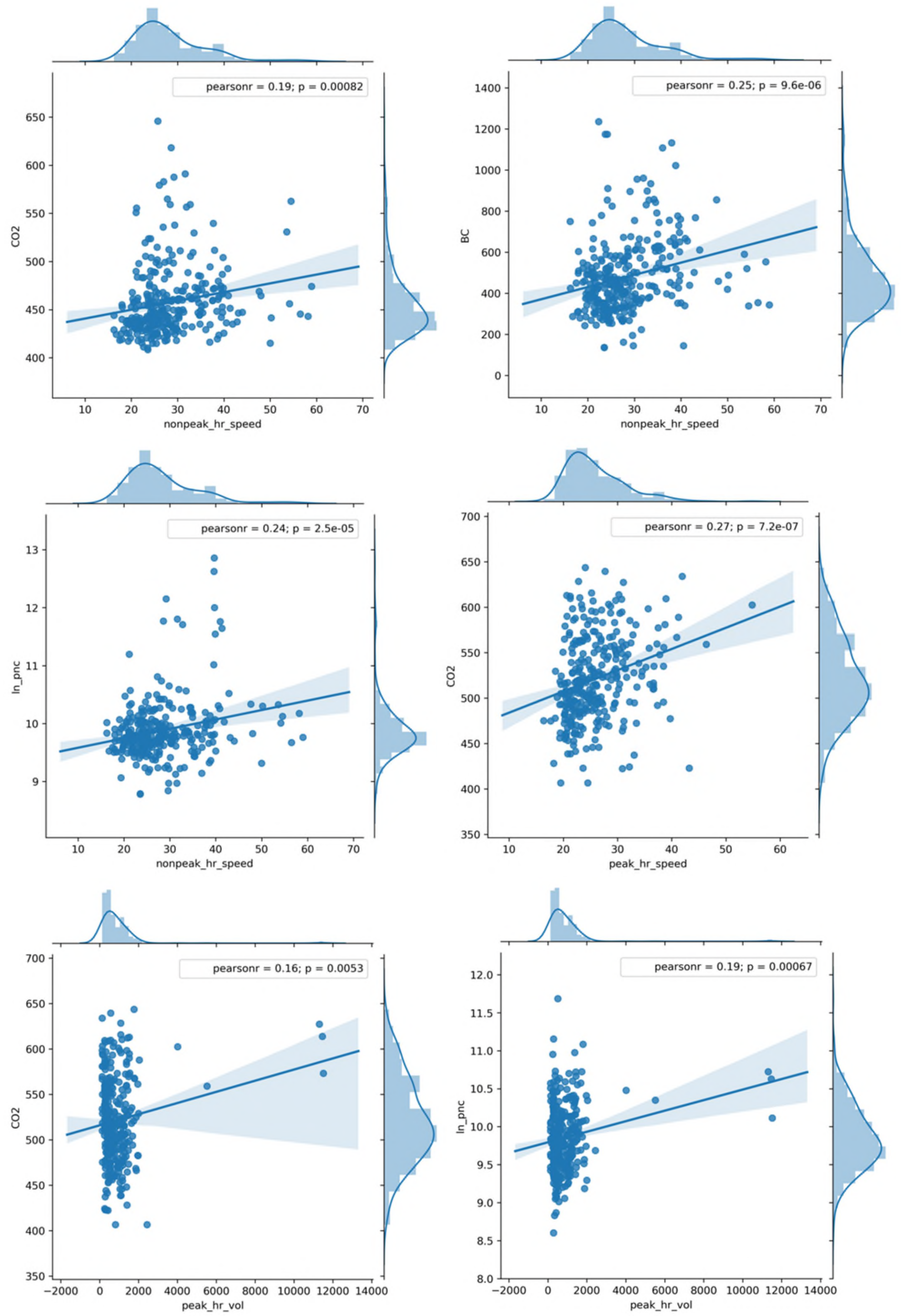

Figure 27: Relationship between Air Quality Measures and Traffic Volume during PM Peak Hours (4-7 PM) and Non-Peak Hours (after 7PM) on Weekdays (Th-F) for Winter (Jan, Feb, 2019). Note: Plots are only shown for those with Pearson Correlation r>0.15.

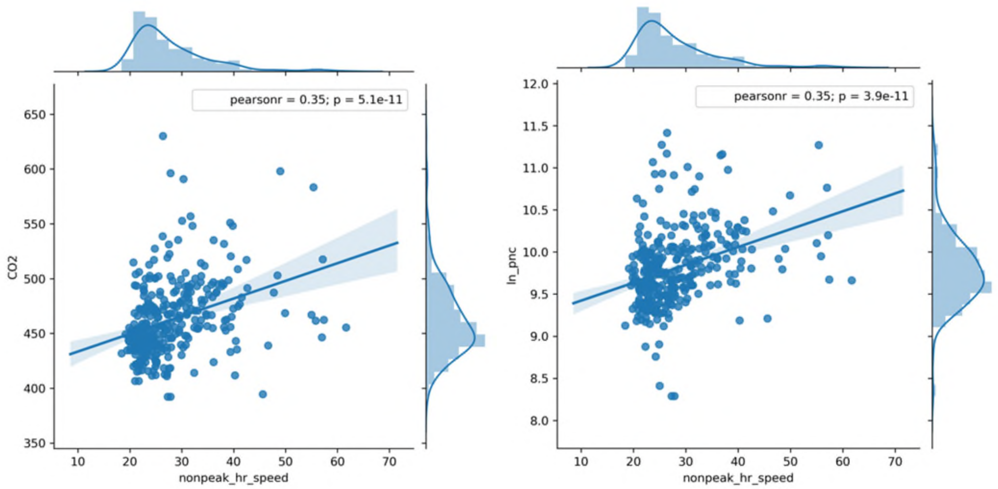

Figure 28*:* **Relationship between Air Quality Measures and Traffic Speed during Non-Peak Hours (10AM -14PM) on Weekends (Saturdays and Sundays) for All Seasons. Note: Plots are only shown for those with Pearson Correlation r>0.15.**

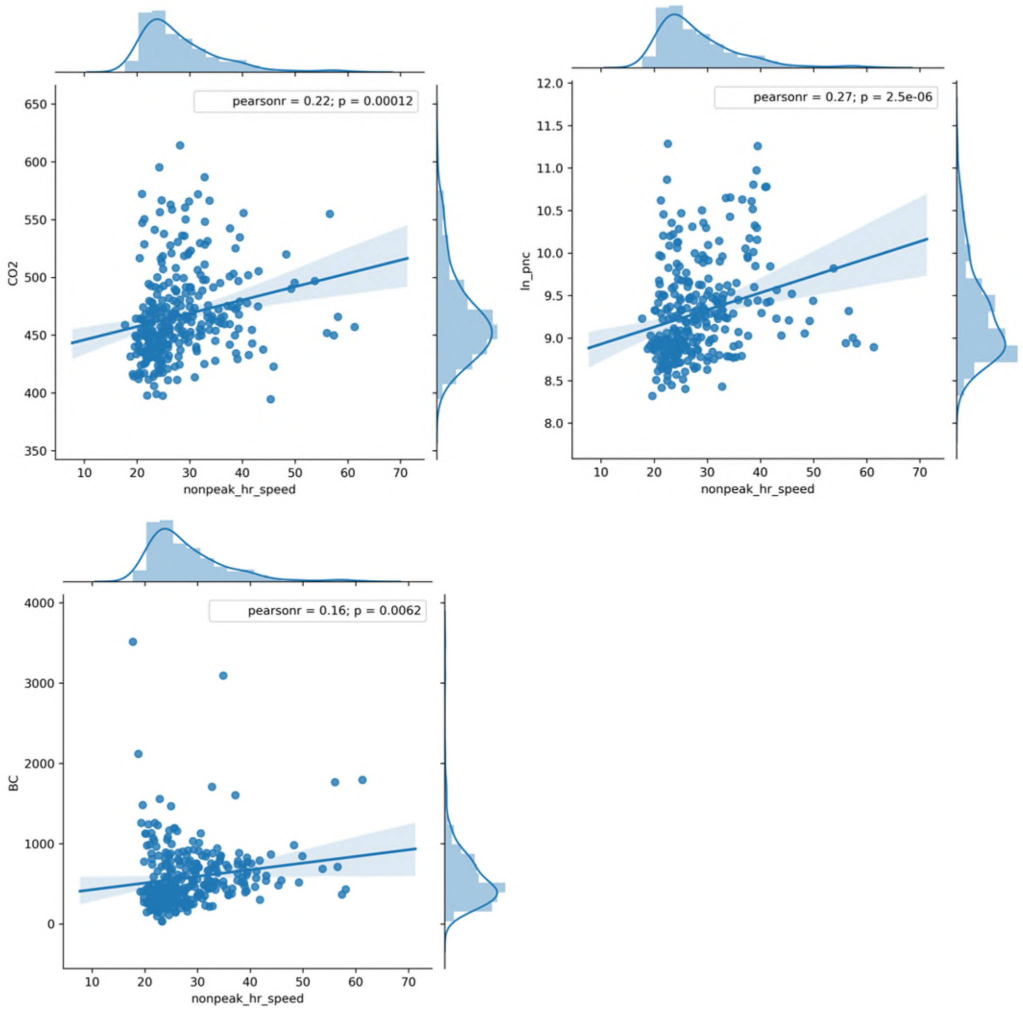

Figure 29: Relationship between Air Quality Measures and Traffic Speed during Non-Peak Hours (10AM -14PM) on Weekends (Saturdays and Sundays) for Fall. Note: Plots are only shown for those with Pearson Correlation r>0.15.

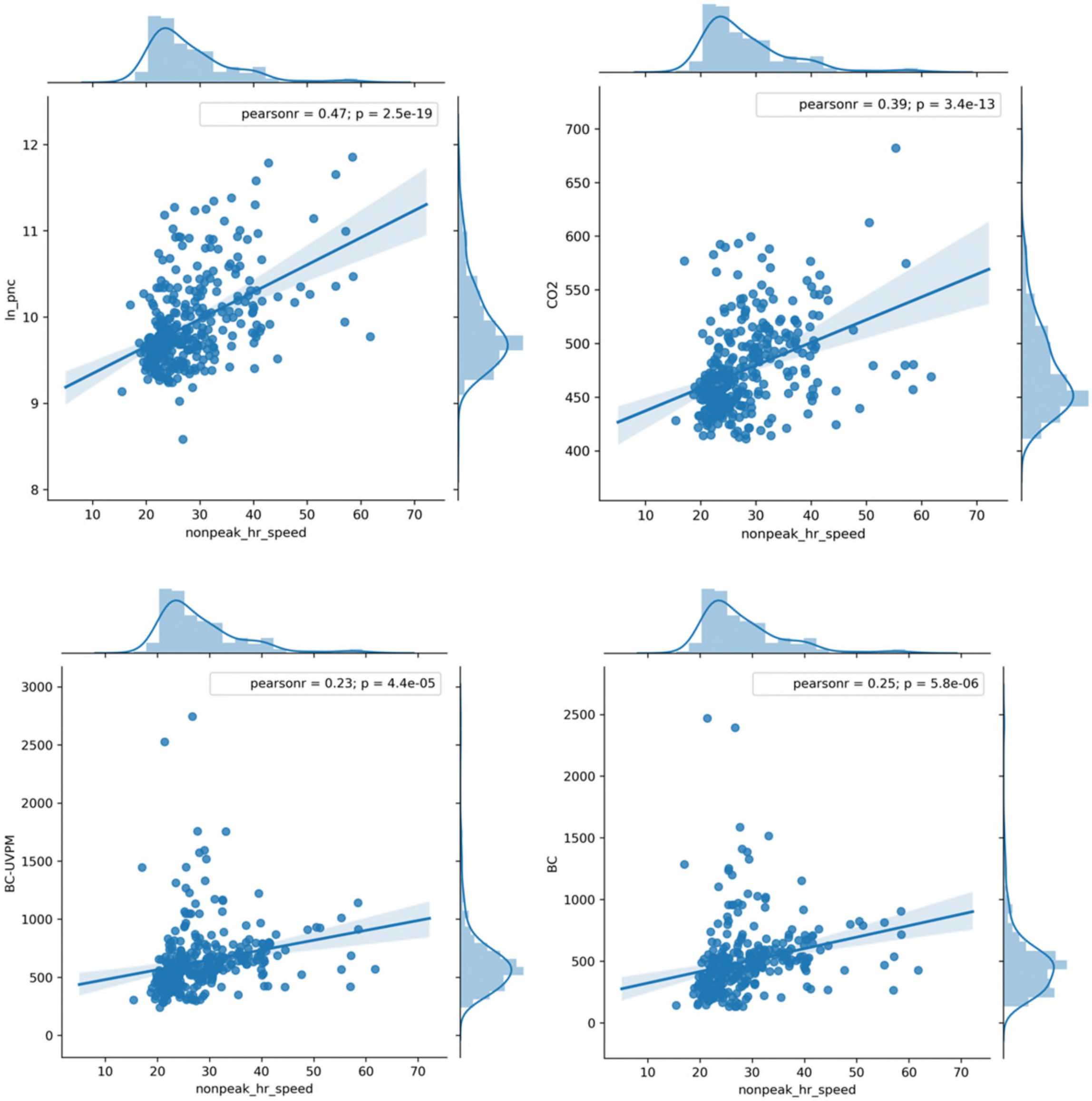

Figure 30*:* **Relationship between Air Quality Measures and Traffic Speed during Non-Peak Hours (10AM -14PM) on Weekends (Saturdays and Sundays) for Winter. Note: Plots are only shown for those with Pearson Correlation r>0.15.**