

Supporting Information for

Impacts of aviation emissions on near-airport residential air quality

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Number of Pages: 34

Number of Figures: 17

Number of Tables: 8

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S1. Methods

S1.1 Preferred Runway Configurations

Red arrows are

Northwest Flow Operating Configuration



Figure 4

descents/landings and yellow arrows are take-offs.

Northeast Flow Operating Configuration



Southeast Flow Operating Configuration



Southwest Flow Operating Configuration



Figure S1: How Logan operates. See: <http://www.massport.com/logan-airport/about-logan/noise-abatement/how-logan-operates/>. Red arrows are descents/landings and yellow arrows are take-offs.

S1.2 Maps of traffic volume estimates around monitoring and regulatory sites

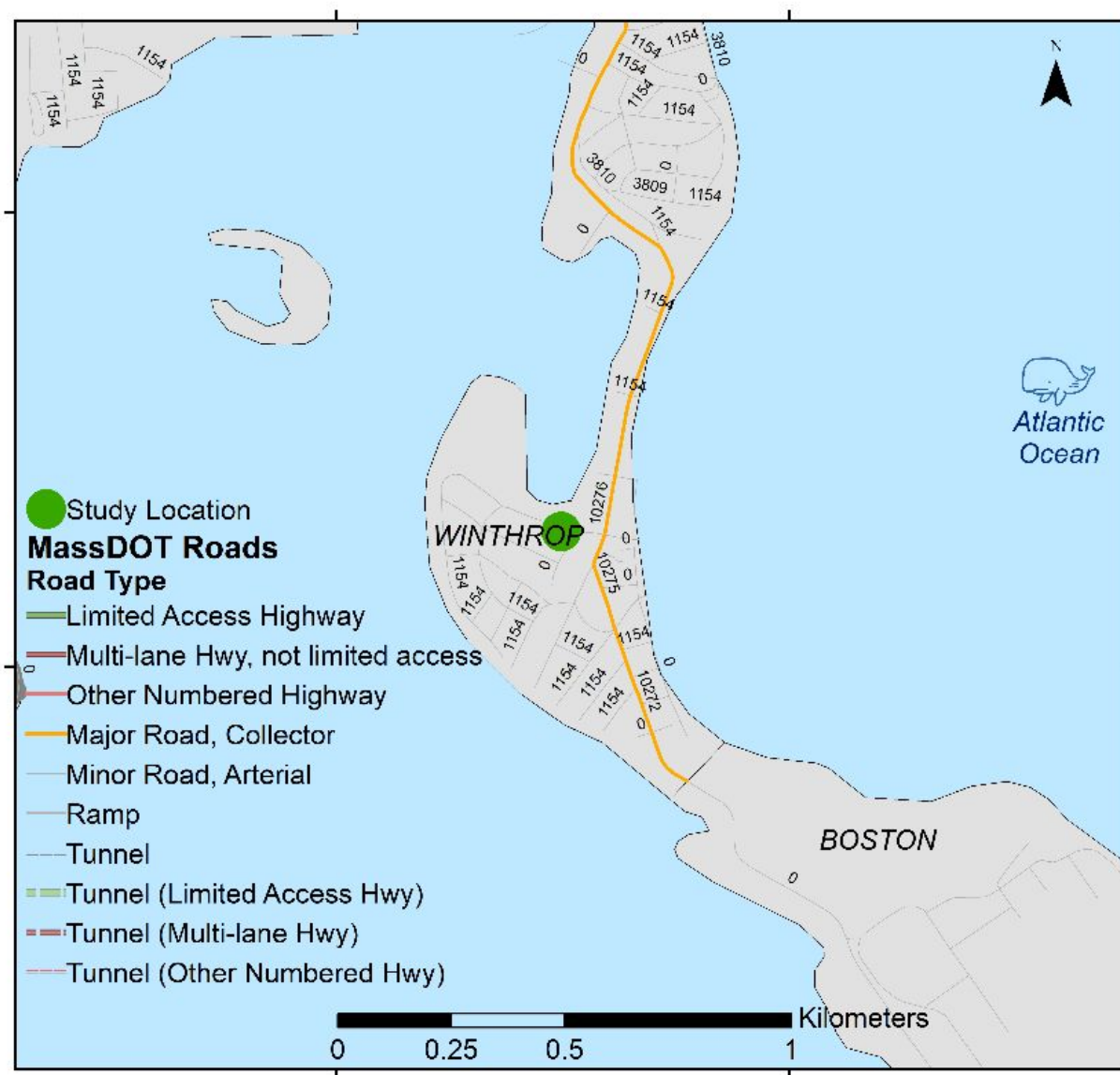


Figure S2a: Location of the monitoring site and annual average daily traffic on nearby roadways (traffic data is Boston Region Metropolitan Planning Organization's Central Transportation Planning Staff estimates¹).

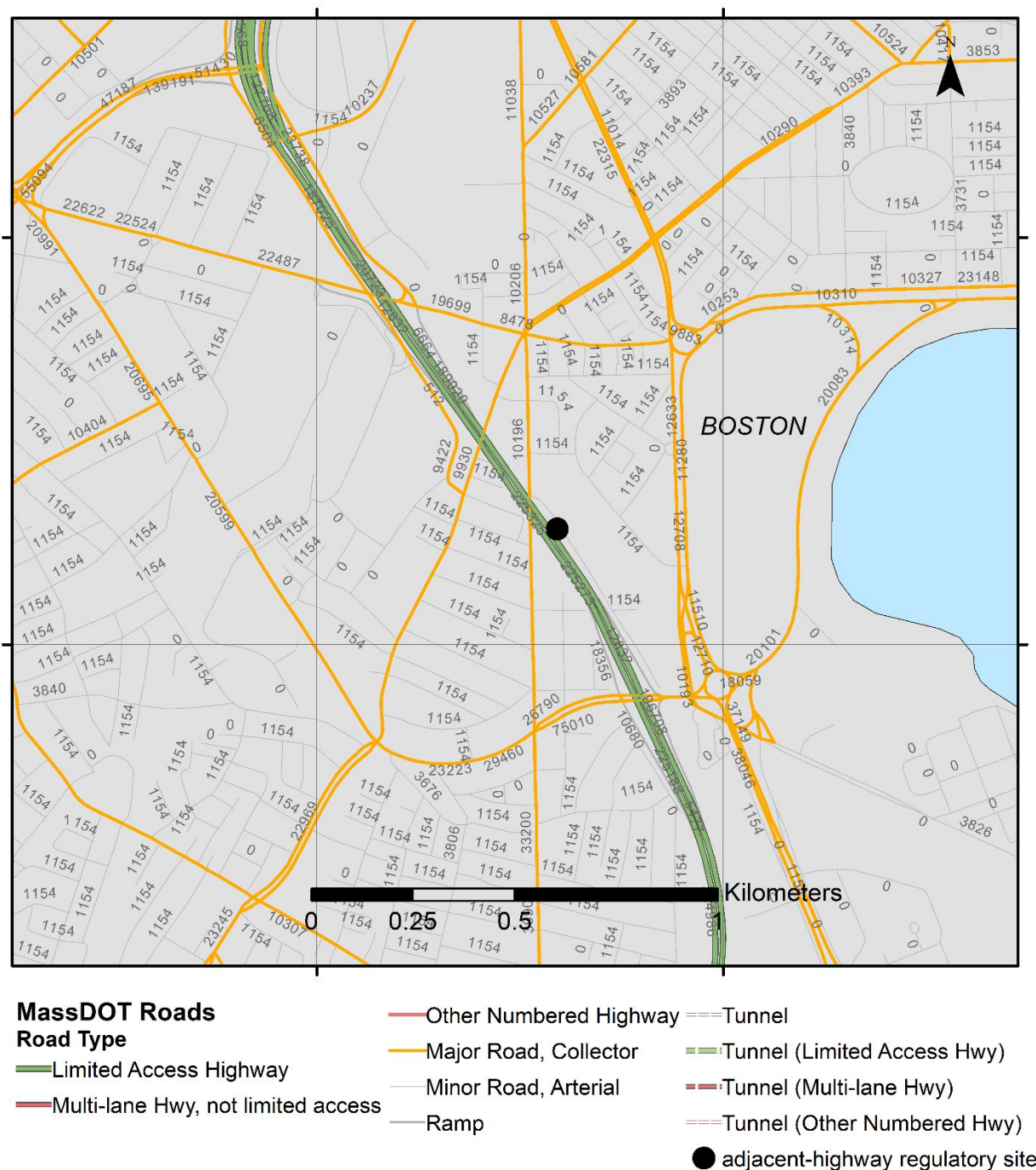


Figure S2b: Location of the adjacent-highway regulatory site and annual average daily traffic on nearby roadways (traffic data is Boston Region Metropolitan Planning Organization's Central Transportation Planning Staff estimates¹).

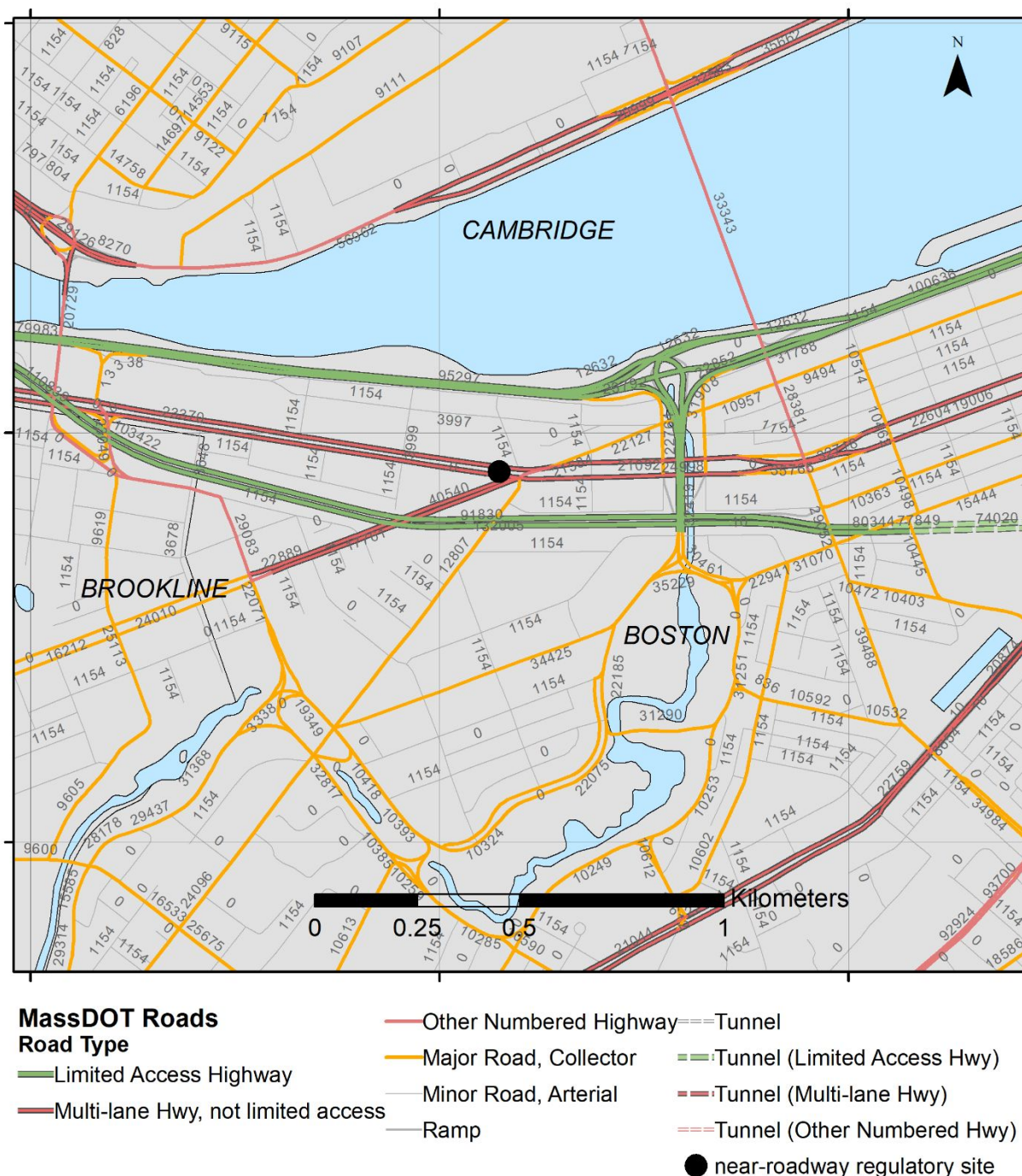


Figure S2c: Location of the near-roadway regulatory site and annual average daily traffic on nearby roadways (traffic data is Boston Region Metropolitan Planning Organization's Central Transportation Planning Staff estimates¹).

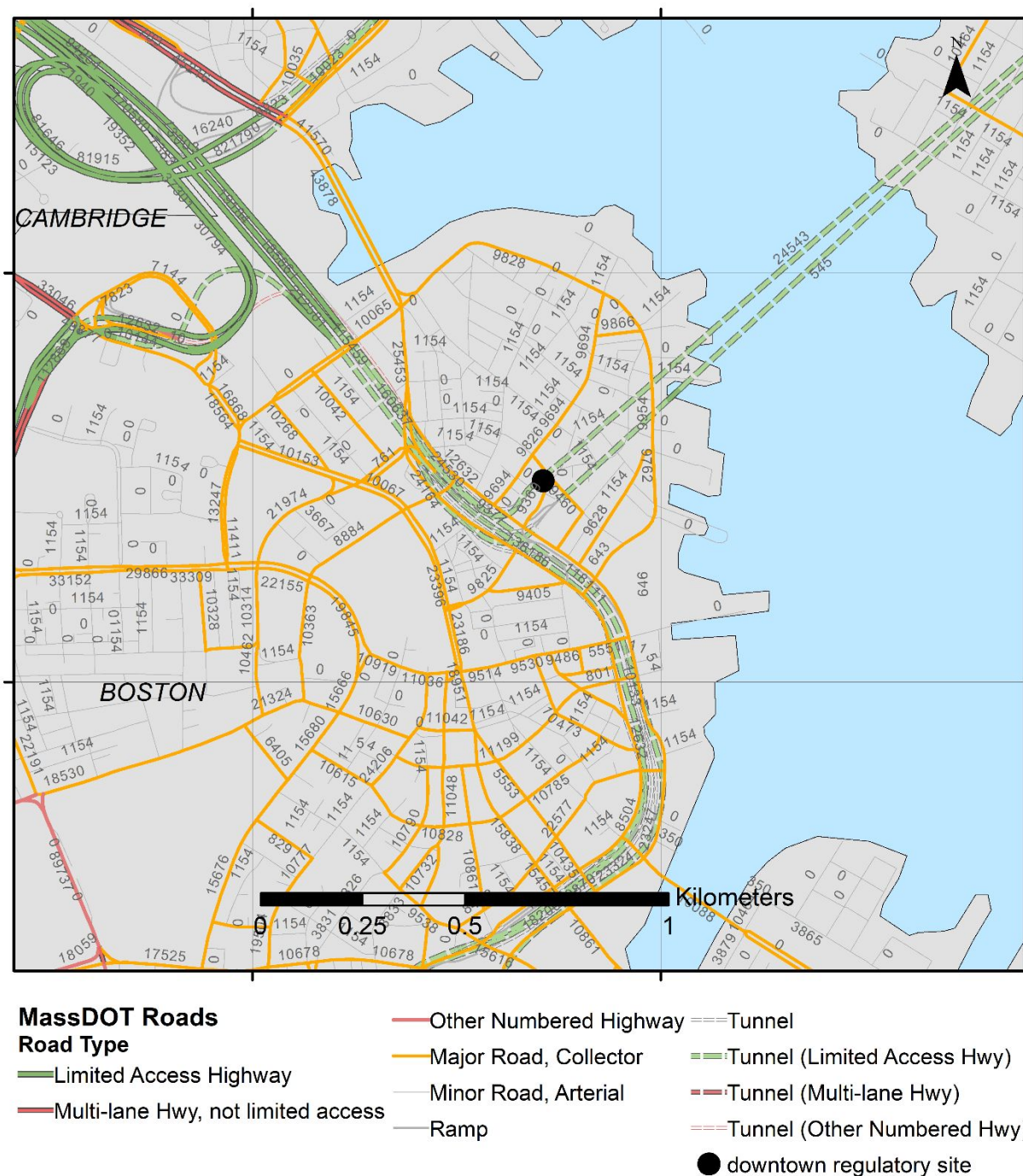


Figure S2d: Location of the downtown regulatory site and annual average daily traffic on nearby roadways (traffic data is Boston Region Metropolitan Planning Organization's Central Transportation Planning Staff estimates¹).

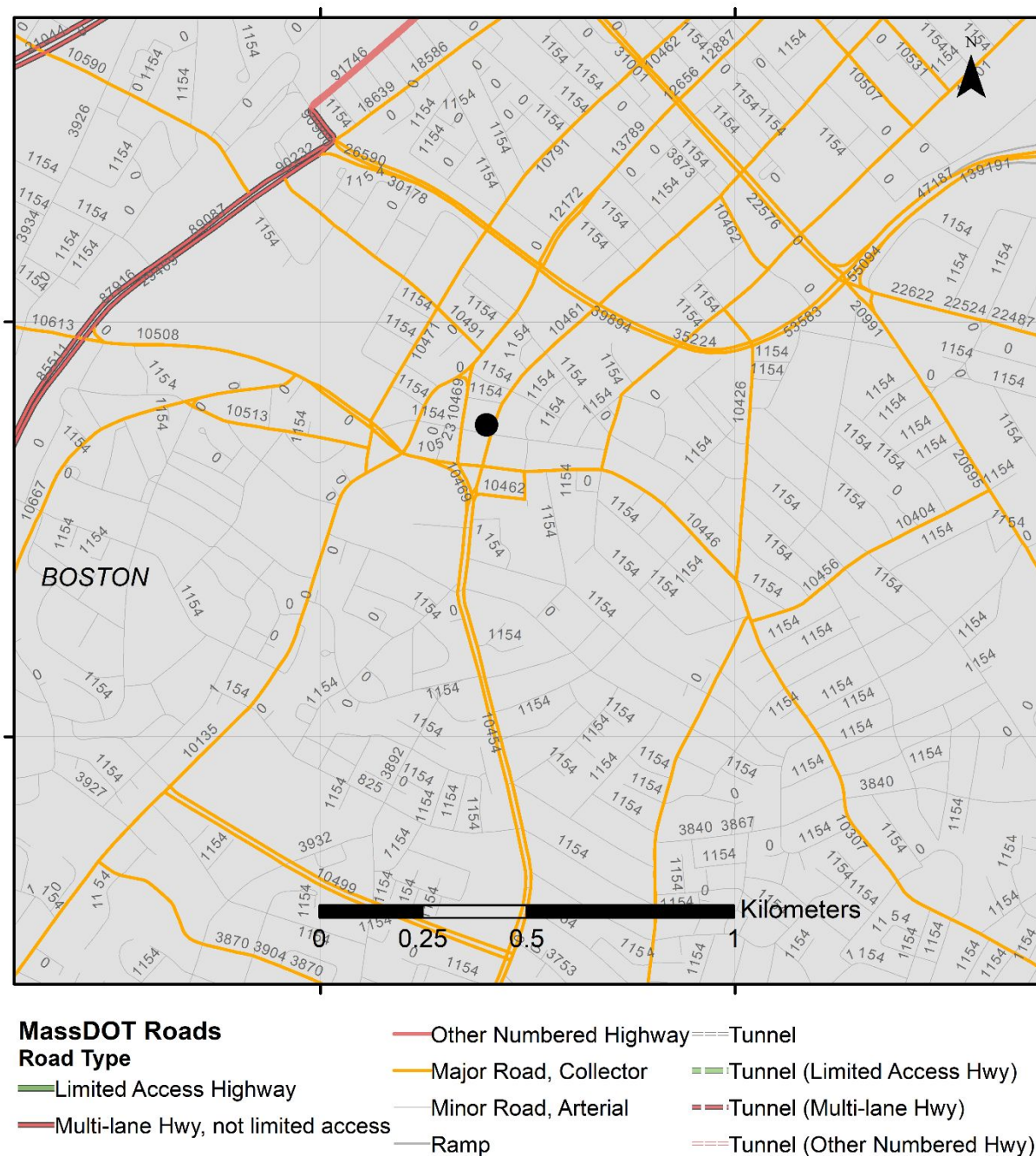
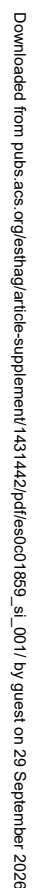


Figure S2e: Location of the urban-background regulatory site and annual average daily traffic on nearby roadways (traffic data is Boston Region Metropolitan Planning Organization's Central Transportation Planning Staff estimates¹).



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S1.3 Instruments

Table S1: Instruments used for monitoring air quality

Parameter	Equipment; manufacturer/model	Relevant Details	Instrument reporting interval (sec)	Averaging time (sec)
Particle number concentration (PNC)	Condensation Particle Counter (CPC); TSI (3783)	Particle Size range: Minimum detectable particle (D_{50}): 7nm Maximum detectable particle: > 3um Concentration Range: 0-10 ⁶ particles/cm ³ (single particle counting) Concentration accuracy: $\pm 10\%$ at 10 ⁶ particles/cm ³	1	1
NO/NO ₂ /NO _x	Chemiluminescence analyzer; Thermo Scientific 42i	Lower Detectable Limit : 0.40 ppb Precision: ± 0.4 ppb	1	10
CO ₂	Carbon dioxide (CO ₂) analyzer; LiCOR (LI-840A)	Measurement Range: 0-20,000 ppm Accuracy: Better than 1.5% of reading RMS Noise at 370 ppm with 1 sec signal filtering: <1 ppm	1	
CO	Gas filter correlation analyzer; Thermo Scientific 48i-TLE	Lower Detectable Limit: 0.04ppm Precision: ± 0.1 ppm	1	10

Particle-bound polycyclic aromatic hydrocarbon (PBPAH) ¹	Photoelectric aerosol sensor; Ecochem Analytics PAS2000	Lower Detectable Limit: 6 femtoamps	8	8
Black carbon (BC)	Aethalometer; Magee Scientific AE-16	Response to 880 nm wavelength Lower Detectable Limit: 0.1 µg/m ³ Resolution: 0.1 µg/m ³ Accuracy: 10%	60	60
PM _{2.5} ²	Laser Photometer; TSI SIDEPAK AM510	90° light scattering, 670 nm laser diode Particle Size Range: 0.1 to 10 µm Minimum Resolution: 0.001 mg/m ³ Aerosol Range: 0.001 to 20 mg/m ³	60	60
¹ The factory calibration for instrument established 0.95 femtoamp signal was equivalent to PBPAH concentration of 1 ng/m ³ . ² The method used to measure particulate matter depends on the relationship between the particulate matter concentration in air and the measured light attenuation. An adjustment factor of 0.6 can be applied to the PM _{2.5} measurements to account for the difference between the density of particles used to calibrate the instrument versus the typical average composition of particles in the metropolitan Boston area (Masri et al., 2015). ¹				

Table S2: Instruments used for monitoring air quality at regulatory sites and traffic volume around the regulatory sites

Site	Regional-background	Downtown	Near-roadway	Urban-background	Adjacent-highway
Latitude	42.474671	42.363069	42.348933	42.3295	42.325186
Longitude	-70.971358	-71.054336	-71.097708	-71.082619	-71.056061
Black carbon PM2.5 STP			Non-Federal Reference; Magee Scientific TAPI M633 Aethalometer-Optical absorption at 1-hour sample duration	Non-Federal Reference; Magee Scientific TAPI M633 Aethalometer-Optical absorption at 1-hour sample duration	Non-Federal Reference; Magee Scientific TAPI M633 Aethalometer-Optical absorption at 1-hour sample duration
Carbon monoxide	Federal Reference; Instrumental- Gas Filter Correlation Teledyne API 300 EU at 1-hour sample duration			Federal Reference; Instrumental-Gas Filter Correlation Teledyne API 300 EU at 1-hour sample duration	Federal Reference; Instrumental-Gas Filter Correlation Teledyne API 300 EU at 1-hour sample duration
Oxides of Nitrogen	Federal Reference; Instrumental- Gas Phase Chemiluminescence at 1 hour sample duration		Federal Reference; Instrumental-Gas Phase Chemiluminescence at 1 hour sample duration	Federal Reference; Instrumental-Gas Phase Chemiluminescence at 1 hour sample duration	Federal Reference; Instrumental-Gas Phase Chemiluminescence at 1 hour sample duration
PM2.5 - Local Conditions*	Federal equivalent method; Met One BAM-1020 Mass Monitor w/VSCC-Beta Attenuation at 1-hour sample duration	Federal equivalent method; Met One BAM-1020 Mass Monitor w/VSCC-Beta Attenuation at 1-hour sample duration	Federal equivalent method; Met One BAM-1020 Mass Monitor w/VSCC-Beta Attenuation at 1-hour sample duration	Federal equivalent method; Met One BAM-1020 Mass Monitor w/VSCC-Beta Attenuation at 1-hour sample duration	Federal equivalent method; Met One BAM-1020 Mass Monitor w/VSCC-Beta Attenuation at 1-hour sample duration

*While the measurements at the regulatory sites were conducted using federal reference or equivalent methods for particle mass, we used an optical sensor which needs to be locally calibrated because the method it uses to measure particulate matter depends on the relationship between the particulate matter concentration in air and the measured light attenuation. An adjustment factor of 0.6 was applied to the PM_{2.5} measurements to account for the difference between the particle densities used to calibrate the instrument versus the typical average composition of particles in the metropolitan Boston area² for plotting in Figure 7 and Table 2.

S1.4 Flight Activity Error Estimate

Table S3: Error in automated scraping of flight activity data

Date	Period	Operations/hour		Operations underestimation by automated methodology
		Automated Count	Visually replayed and counted	
2-Sep	5-6 PM	67	67	0
11-Sep	5-6 AM	21	21	0
11-Sep	9-10 AM	62	64	2
11-Sep	6-7 PM	85	86	1
11-Sep	11 PM - 12 AM	23	23	0

S2. Results

S2.1 Summary of concentrations during impact sector and non-impact-sector winds

Table S4: Statistics for hourly averaged pollutant concentrations during the monitoring period (Aug 23 – Sep 23, 2017) for three wind sectors: impact-sector (247°–360°), mostly over-the-ocean (0°–112.5°) and mostly over-the-land (112.6°–246.9°) wind sectors.

Pollutant	n (hours of data)			Mean ($\pm$ St. Dev.)		
	Impact sector	Over-the-land	Over-the-ocean	Impact sector	Over-the-land	Over-the-ocean
PNC indoors (10^3 number/cm ³)	261	202	282	25 $\pm$ 27	12 $\pm$ 18	4.7 $\pm$ 11
PNC outdoors (10^3 number/cm ³)	255	215	254	38 $\pm$ 42	8.5 $\pm$ 9.6	4.2 $\pm$ 5.2
PNC I/O ratio	255	201	248	0.77 $\pm$ 0.27	0.88 $\pm$ 0.72	1.1 $\pm$ 1.4
BC (ng/m ³)	141	116	254	390 $\pm$ 230	450 $\pm$ 310	230 $\pm$ 180
PBPAH (ng/m ³)	159	82	147	1.8 $\pm$ 1.9	1.4 $\pm$ 1.4	0.8 $\pm$ 0.8
PM _{2.5} (mg/m ³)*	251	179	240	0.011 $\pm$ 0.004	0.016 $\pm$ 0.008	0.014 $\pm$ 0.007
NO (ppb)	252	178	241	2 $\pm$ 3	1 $\pm$ 3	0.6 $\pm$ 0.8
NO ₂ (ppb)	252	178	241	17 $\pm$ 7	16 $\pm$ 5	13 $\pm$ 4
NO _x (ppb)	252	178	241	18 $\pm$ 8	17 $\pm$ 7	13 $\pm$ 4
CO (ppb)	196	169	232	220 $\pm$ 50	230 $\pm$ 60	170 $\pm$ 40
CO ₂ (ppb)	209	163	202	381 $\pm$ 10	377 $\pm$ 8	378 $\pm$ 9

* factory calibration based. The method used to measure particulate matter depends on the relationship between the particulate matter concentration in air and the measured light attenuation. An adjustment factor of 0.6 can be applied to the PM_{2.5} measurements reported above to account for the difference between the density of particles used to calibrate the instrument versus the typical average composition of particles in the metropolitan Boston area (Masri et al., 2015).¹

S2.2 PM_{2.5} Trends

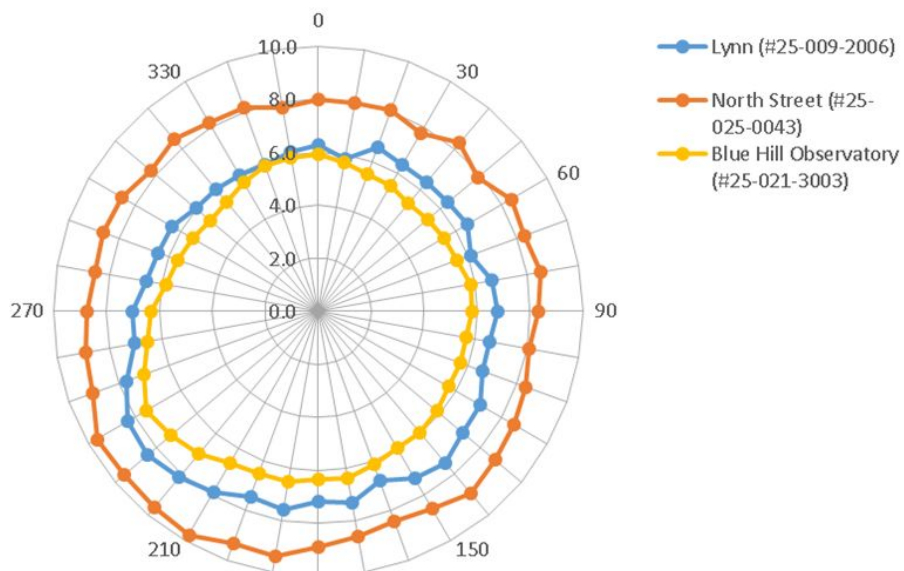


Figure S3a: The annual average PM_{2.5} concentration rose for three regulatory sites in the greater Boston metropolitan area. Data is plotted in units of $\mu\text{g}/\text{m}^3$ (shown on the radial axis from 0 at the center to 10 at the circumference).

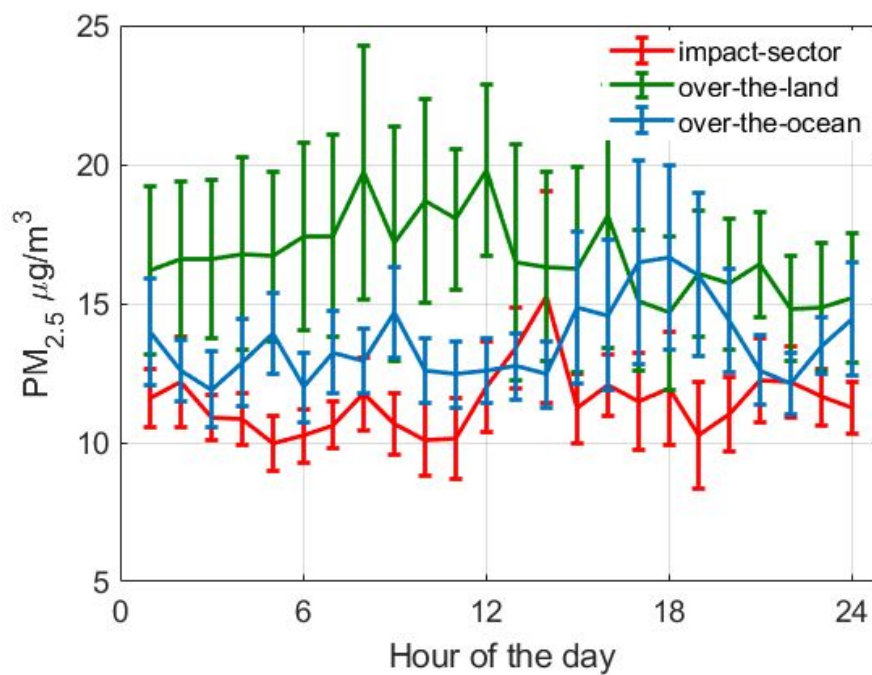


Figure S3b: $PM_{2.5}$ diurnal pattern for the study duration during wind from three sectors: impact-sector (247° - 360°), mostly over-the-ocean (0° - 112.5°) and mostly over-the-land (112.6° - 246.9°) wind sectors. Error bars show standard error.

S2.3 Trends for Other Pollutants and Temperature

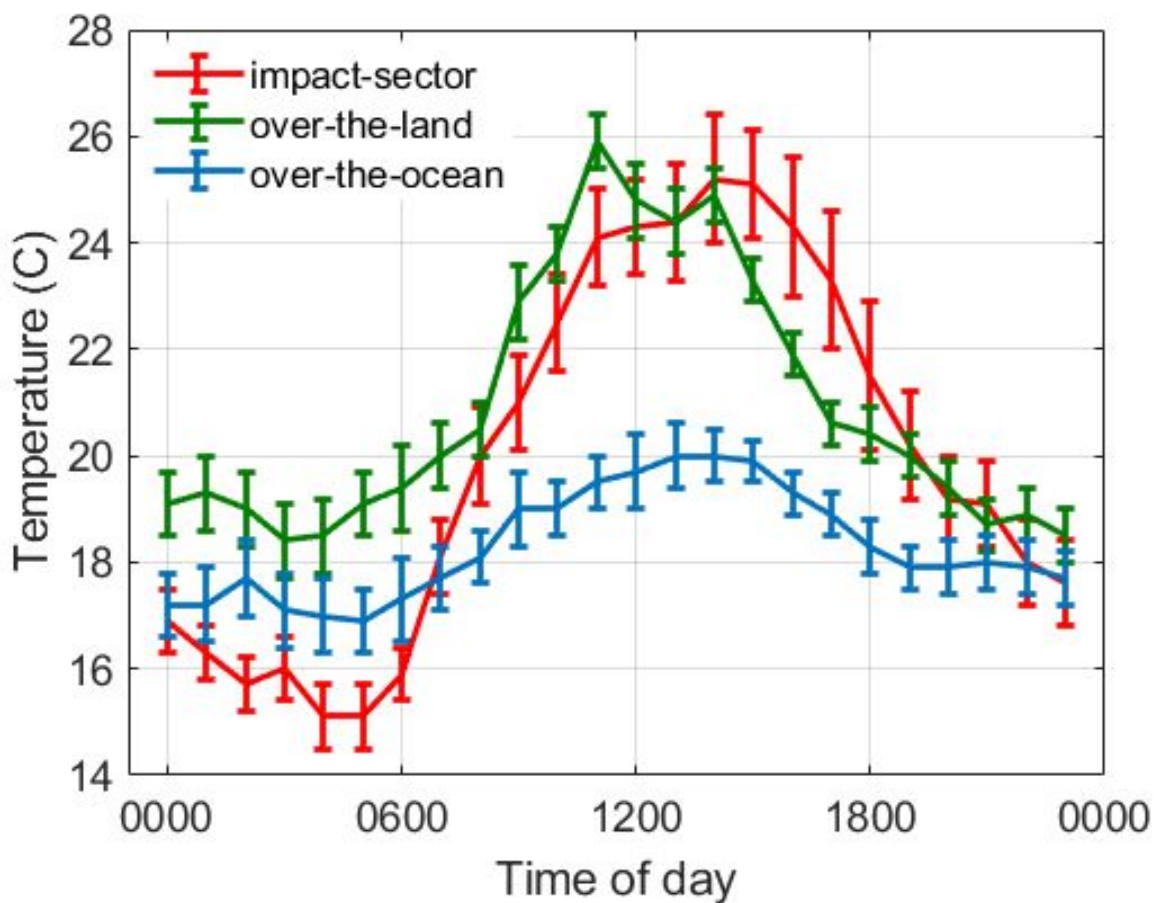


Figure S4: Study-duration diurnal pattern of ambient temperature measures at the airport during wind from three sectors: impact-sector (247° - 360°), mostly over-the-ocean (0° - 112.5°) and mostly over-the-land (112.6° - 246.9°) wind sectors. Error bars show standard error.

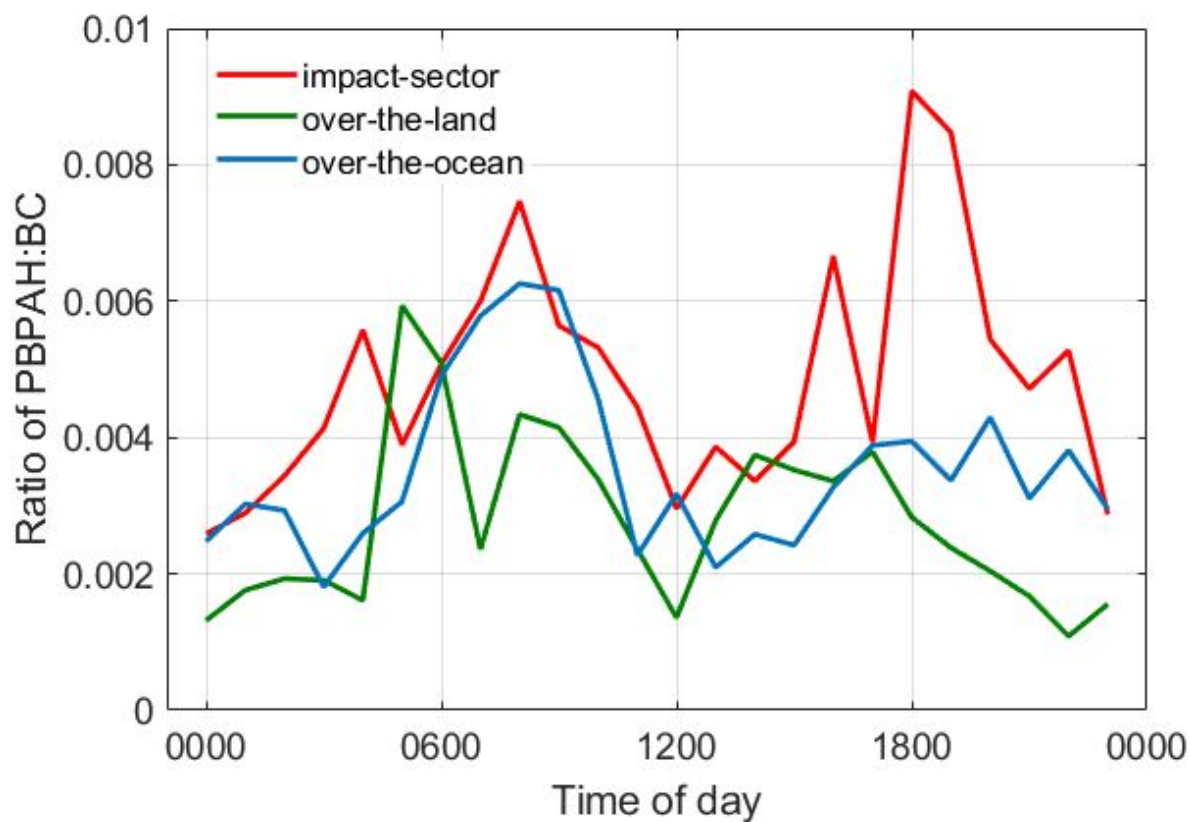


Figure S5: Study-duration average diurnal pattern of ratios of PBPAH to BC concentrations during wind from three sectors: impact-sector (247° - 360°), mostly over-the-ocean (0° - 112.5°) and mostly over-the-land (112.6° - 246.9°) wind sectors.

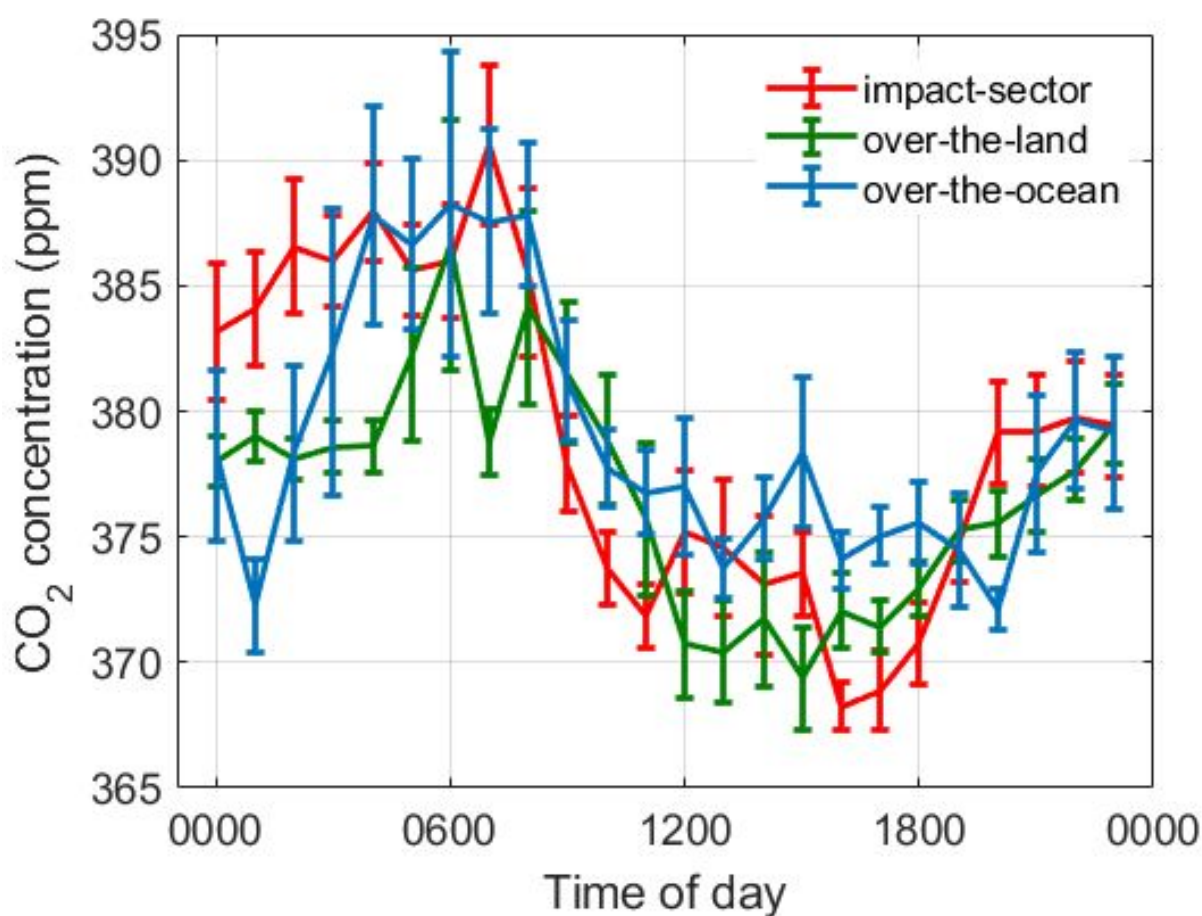


Figure S6: Study-duration diurnal pattern of CO_2 concentrations during wind from three sectors: impact-sector (247° - 360°), mostly over-the-ocean (0° - 112.5°) and mostly over-the-land (112.6° - 246.9°) wind sectors. Error bars show standard error.

S2.4 Correlation Coefficients for Correlation across Pollutants

Figure S7 shows the correlations between pollutants at hourly time-resolution for impact-sector ($n_{\text{max}} = 255$ hours depending on the pollutant), non-impact sector/over-the-ocean winds ($n_{\text{max}} = 288$ hours) and non-impact sector/overland winds ($n_{\text{max}} = 205$ hours).

Because the pollutants we monitored largely derive from fossil-fuel combustion, they are expected to be highly correlated. Overall, higher correlations were observed for outdoor pollutants during over-the-ocean winds compared to impact-sector or over-the-land winds. (Similarities in diurnal profiles of pollutants are also apparent in Figure 4 of the manuscript) The varied, pollutant-specific influence of dispersion dynamics and atmospheric processing could have resulted in lower correlations between the pollutants at the near-source site (i.e., at the near-airport residence during impact-sector winds)

compared to that observed for well-mixed plumes of distant sources in mostly over-the-ocean winds. However, outdoor and indoor UFP were highly correlated (even more so during impact-sector winds ($r_s = 0.95$) than other wind sectors ($r_s = 0.78$ - 0.79) indicative of the outdoor-origin of indoor UFP.

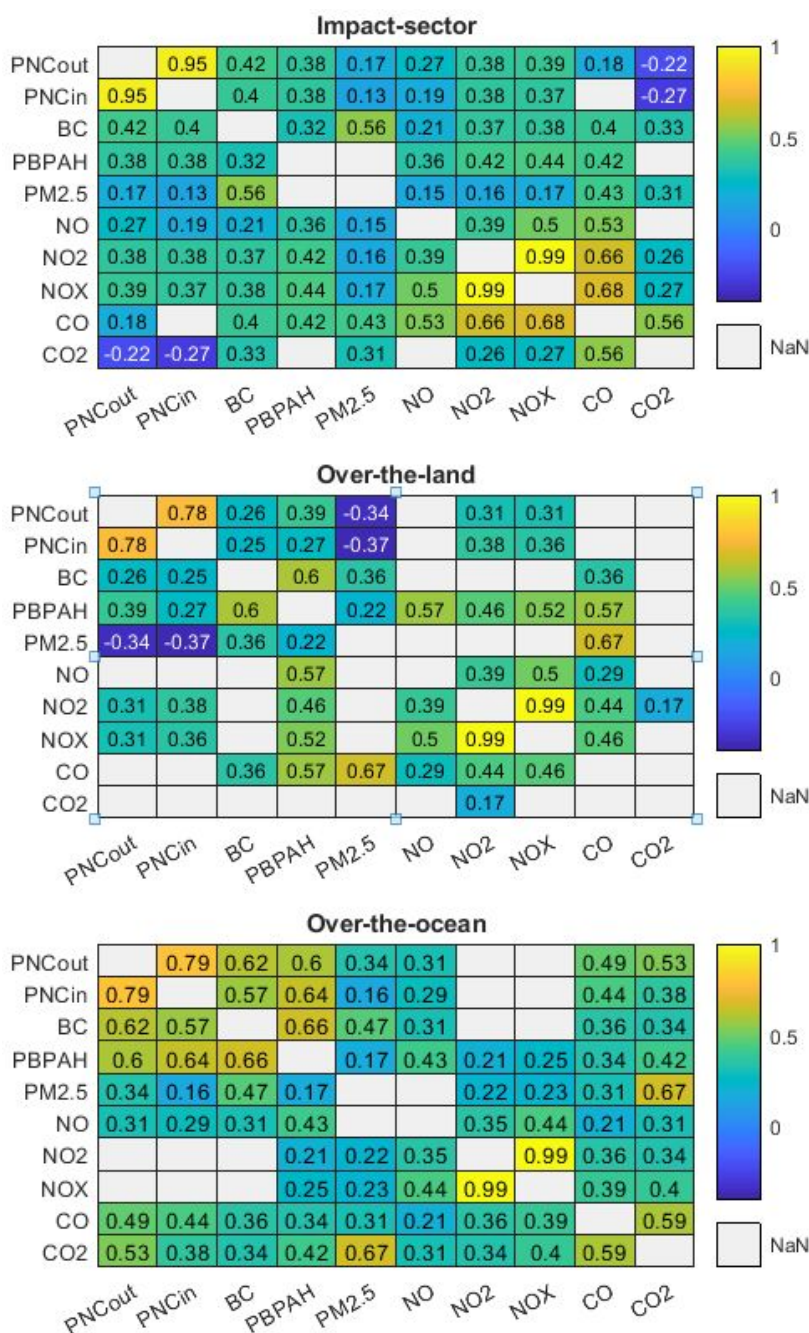


Figure S7: Correlograms for spearman's correlation across pollutants during three wind sectors: impact-sector (247° - 360°), mostly over-the-ocean (0° - 112.5°) and mostly over-the-land (112.6° - 246.9°) wind sector.

S2.5 Particle Infiltration

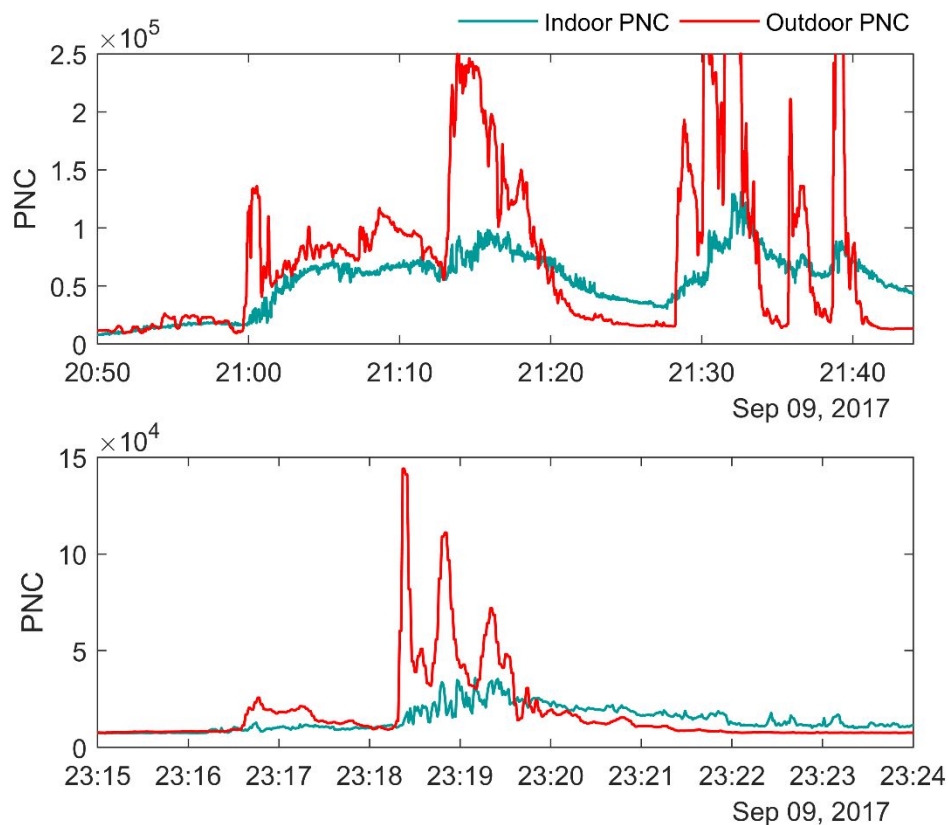


Figure S8: Time-series example for PNC (high-resolution 1-s averages have been plotted) showing that infiltration occurs on the order of minutes.

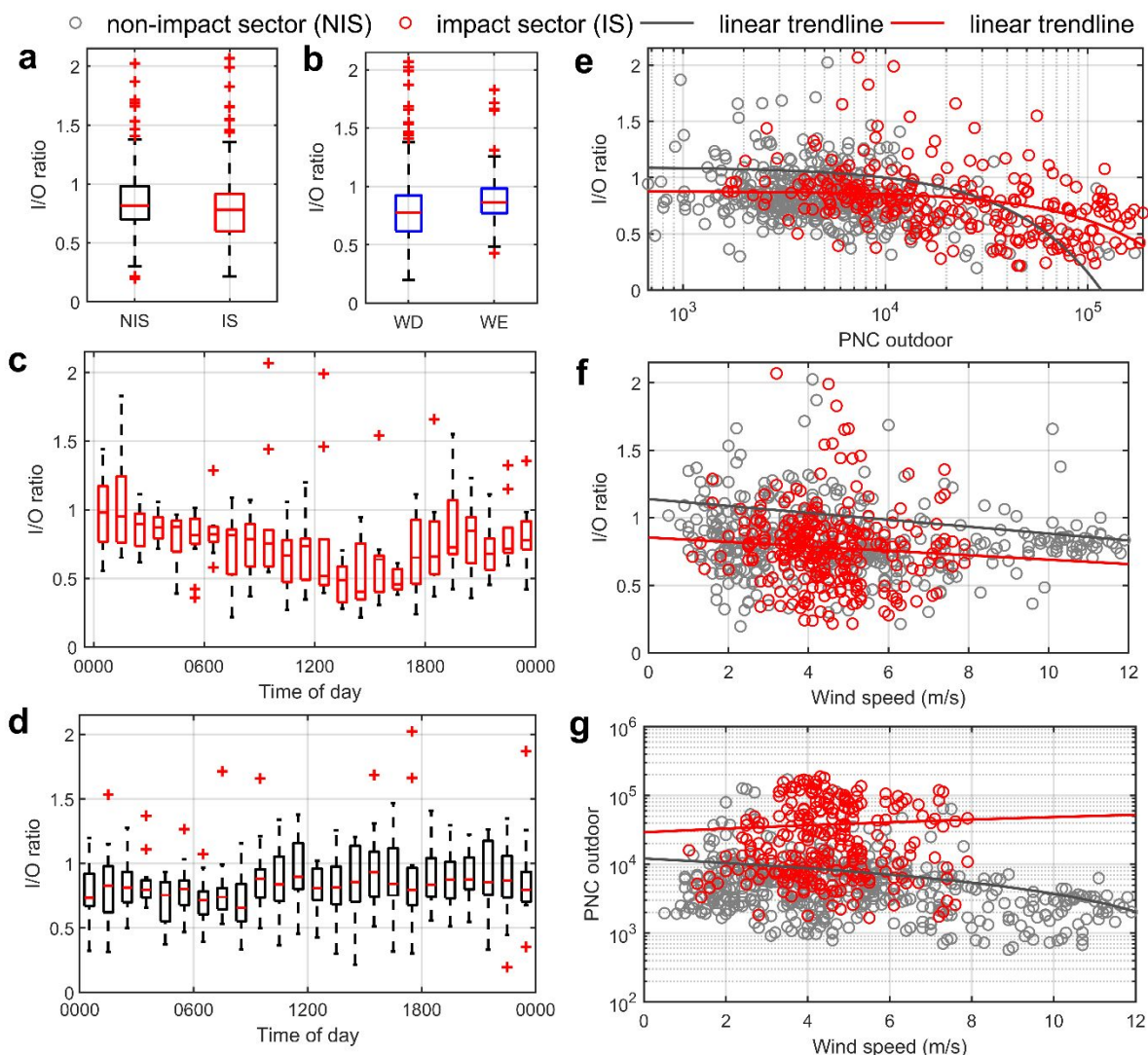


Figure S9: Tukey's boxplot for I/O ratios for the study period (a) split by impact-sector (IS) and non-impact-sector winds (NIS), (b) split by weekday (WD) and weekend (WE), (c)-(d) for impact-sector (red boxplots) and non-impact-sector (black boxplots) data showing the diurnal pattern.

Resident's indoor activities and ventilation practices were also modifiers of I/O ratios. In our survey the residents (two adults who were away from the house from 0800-1800 hours Monday through Friday) indicated that on weekdays windows were opened minimally during the day and in the evening, while on weekends 3-4 windows were typically opened for 2-5 hours during the day and 1-2 hours in the evening. At night on both weekdays and weekends all windows were closed and as many as three window-mounted AC units were operated to provide cooling. Also, the residents indicated they cooked infrequently. We tested differences between weekends and weekdays. On weekends (n=8 days; 4 Saturdays and 4 Sundays), PNC I/O ratios were

significantly higher than on weekdays ($n=24$ days) independent of wind direction (overall average 0.89 ± 0.20 on weekends vs 0.77 ± 0.26 on weekdays; $p<0.0001$; Figure S9b).

Trends with respect to hour of the day were not apparent when the data was stratified by weekends vs. weekdays (Figure S10); however, when the data was stratified by wind direction distinct differences were observed (Figure S9c and S9d). During impact-sector winds, I/O ratios were as low as -0.5 in the afternoon (1300-1500 hours) and as high as -0.9 at midnight, while during non-impact-sector winds I/O ratios were generally uniform but below average during the early morning (0100-0500 hours). Trends with respect to time of day for data stratified by both weekday/weekend and impact-sector/non-impact-sector winds are shown in Figure S11.

I/O ratios also exhibited a slight negative trend with respect to wind speed (Figure S9f): $r_s = -0.16$ [$p=0.0754$], -0.11 [$p<0.0001$], -0.15 [$p<0.0001$] for impact-sector winds ($n = 255$ hours), non-impact-sector winds ($n = 450$ hours) and overall ($n = 705$ hours), respectively. PNC were expectedly negatively correlated with wind speed during non-impact-sector winds ($r_s = -0.19$, $p\text{-value}<0.0001$) but did not decrease at higher wind speeds ($r_s = 0.06$, $p\text{-value} = 0.35$) during impact-sector winds. This trend was reported previously^{3,4} and is associated with buoyant plumes,⁵ like those from aircrafts (Figure S9g).

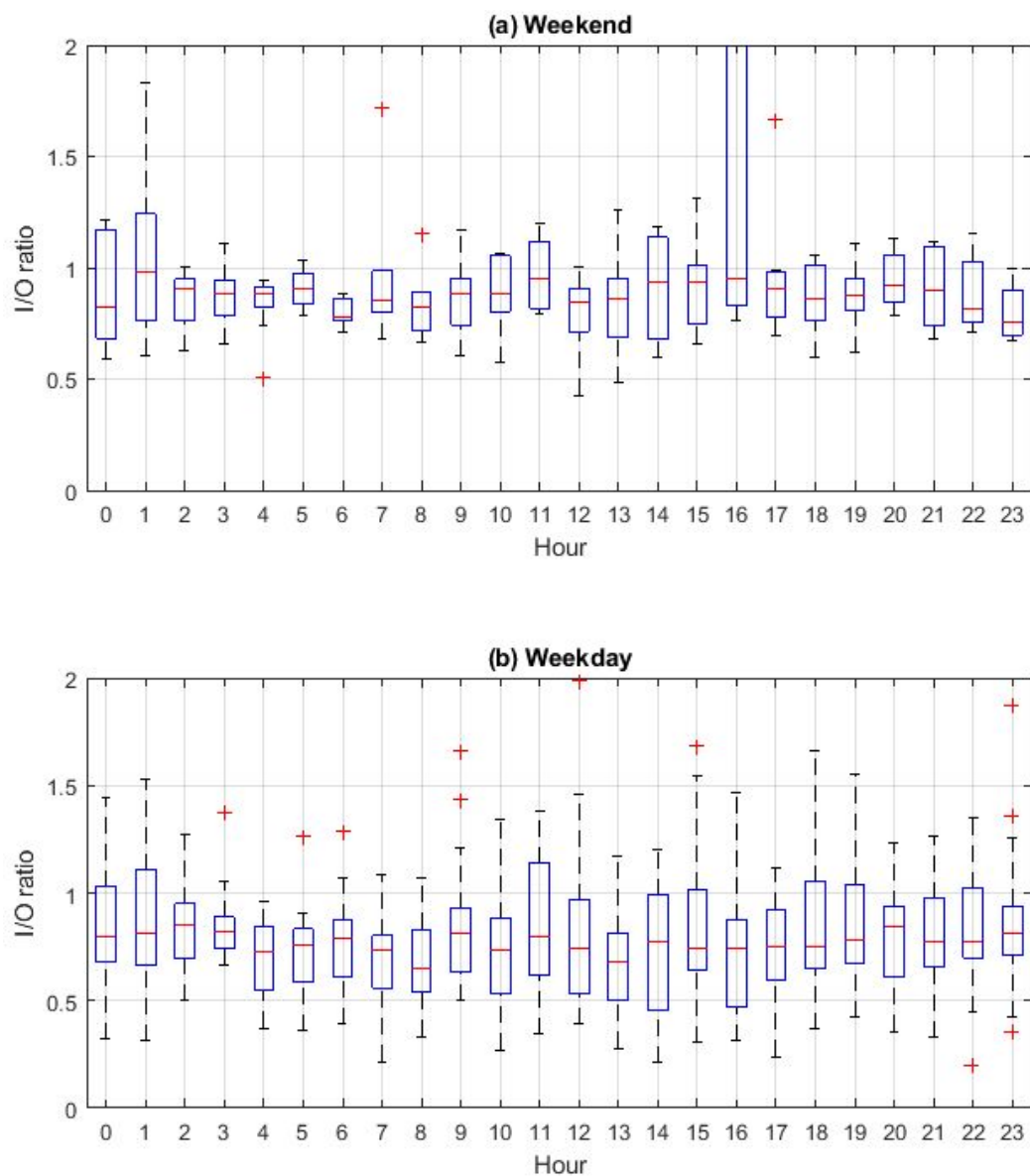


Figure S10: Tukey's boxplots of PNC I/O ratios by time of day.

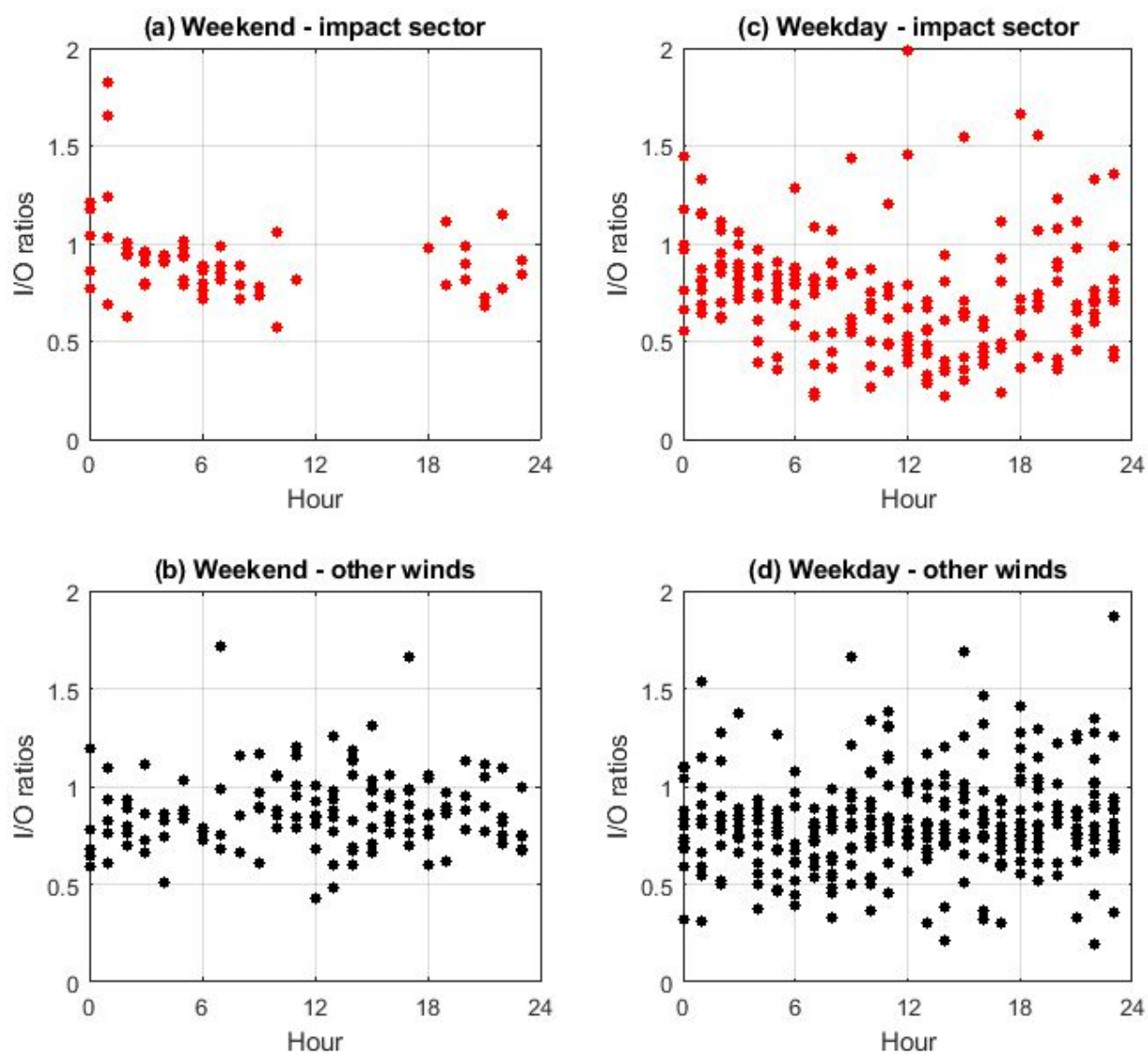


Figure S11: Pattern of I/O ratios by time of day.

S2.6 Flight Activity on Preferred Runways and Pollutant Patterns during Impact Sector Winds

S2.6.1 Correlation between Flight Activity and Pollutants

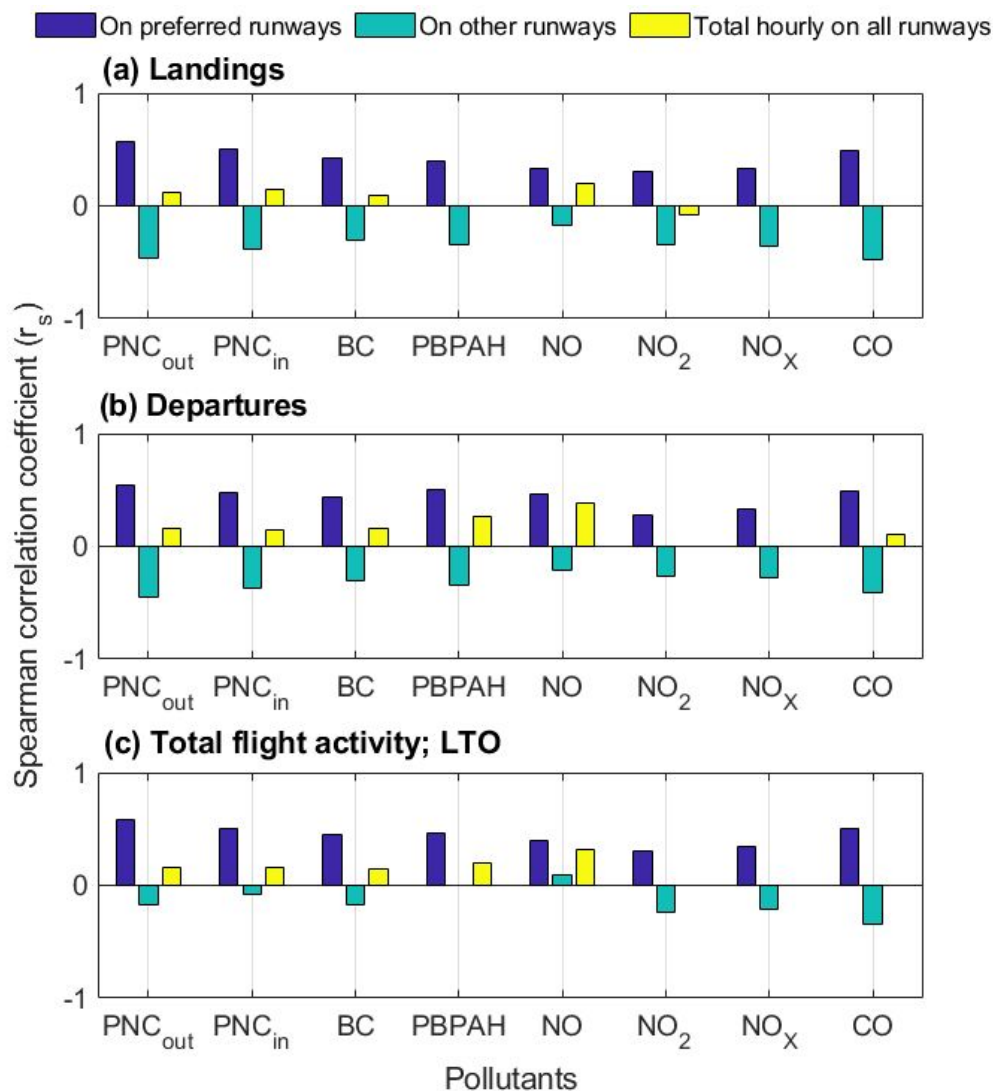


Figure S12: Spearman's correlation coefficients (if significant, i.e., $p < 0.05$) between hourly average pollutant concentrations and hourly flight operations during impact-sector winds ($n = 262$ h) for the flight activity on preferred runways (i.e., runways 33L, 32, 27, 22R & 22L), flight activity on other runways (15R, 9, 4L & 4R) and total hourly flight activity on all runways.

Positive correlations were only observed for overhead landings on 27 (directly overhead) (outdoor PNC [$r_s = 0.7$ and 0.6 post control]) and takeoffs on 33L (one of the two nearest possible takeoff location to the study site)(outdoor PNC [$r_s = 0.5$ and 0.2 post control] and BC [$r_s = 0.4$

and 0.3 post control]). These remained significant and positive even after controlling for effects of activity on all other runways. In contrast, for the hours when landings were on 33L and takeoffs on 27 (Figures 5b-5c), i.e., still on the two closest runways but jets weren't descending overhead correlations were low.

Similarly, for the entire impact-sector dataset, the strongest correlations between flight activity on individual runways and pollutant concentrations were also observed for overhead landings on 27 and takeoffs on 33L. Even after controlling for the effects of takeoffs and landings on each of the other runways individually, overhead landings on 27 were positively correlated with outdoor PNC ($r_s = 0.35$) and indoor PNC ($r_s = 0.36$), and takeoffs on 33L were positively correlated with BC ($r_s = 0.41$), outdoor PNC ($r_s = 0.32$) and indoor PNC ($r_s = 0.30$).

Correlations between flight activity on all runways and all pollutants are summarized in Tables S5-S7. Since activity occurs simultaneously on multiple runways and observed pollutant concentration data reflects cumulative contributions, partial correlations controlling for effects of activity (landings and takeoffs) on all other runways are reported in Table S7.

*Table S5: Spearman's correlation coefficients (reported if significant, i.e., p -value < 0.05) between hourly average pollutant concentrations and hourly **takeoffs** on all active runways.*

Pollutants	15R	4L	4R	9	22R	22L	27	32	33L
PNC -outdoor	-0.18	-0.29	-0.28	-0.45	0.17	0.19	0.15		0.48
PNC-indoor	-0.11	-0.27	-0.26	-0.37	0.12	0.13	0.12		0.48
BC	0.14	-0.23	-0.36	-0.30	0.21	0.30	0.15		0.27
PBPAH	-0.16	-0.22	-0.17	-0.31	0.14	0.16	0.28		0.32
NO	-0.21	-0.10	-0.14	-0.13	0.19	0.15	0.42		0.26
NO ₂	-0.09	-0.26	-0.11	-0.31	0.23	0.26	0.12		0.11
NO _x	-0.11	-0.26	-0.13	-0.31	0.24	0.26	0.17		0.14
CO		-0.29	-0.28	-0.44	0.31	0.45	0.16		0.14

*Table S6: Spearman's correlation coefficients (reported if significant, i.e., p -value < 0.05) between hourly average pollutant concentrations and hourly **landings** on active runways. Note, 22R is used for non-jet arrivals only.*

Pollutants	15R	4L	4R	9	22R (non-jet)	22L	27	32	33L
PNC-outdoor	-0.13	-0.19	-0.46		0.18		0.55	0.33	0.25
PNC-indoor	-0.09	-0.20	-0.37		0.10		0.55	0.34	0.21
BC		-0.12	-0.34		0.30	0.15	0.22		0.18
PBPAH		-0.14	-0.35		0.14		0.25		0.20
NO			-0.16		0.13	0.10	0.11		0.21
NO ₂	-0.12	-0.18	-0.34		0.25		0.17	-0.09	0.14
NO _x	-0.13	-0.18	-0.34		0.26		0.16	-0.09	0.16
CO	-0.15	-0.16	-0.48		0.46	0.17	0.21		0.15

Table S7: Spearman's correlation coefficients (reported if significant, i.e., p -value < 0.05) between hourly average pollutant concentrations and hourly takeoffs or landings on active runways controlling for effects of activity, both takeoffs and landings, individually on all other runways (i.e., partial correlation coefficients).

	Takeoffs					Landings		
	27	32	33L	4L	4R	27	32	4L
PNC-outdoor			0.32			0.35	-0.17	
PNC-indoor			0.30			0.36	-0.21	0.14
BC			0.41			-0.26		
PBPAH	0.17							
NO	0.32		0.18	0.13				
NO ₂		0.15			0.19		-0.26	
NO _X		0.14			0.16		-0.25	
CO						-0.18	-0.18	

S2.6.2 Time-series for Other Pollutants

Figures S13-S16 show data for the same 24-hour period that is shown in Figure 5a of the manuscript. Majority of flight activity was on runways 27 and 33L. These are the two closest runways to our monitoring site. They are also preferred for operations during impact-sector winds (Figure 1a). One key difference over the course of the day was that between 0400-1700 hours 70-100% of operations/hour occurred such that landings were on 33L and takeoffs on 27, but between 1700-0000 hours the runway configuration switched and 80-100% of operations/hour occurred such that landings were on 27 (i.e., overhead of our monitoring site) and takeoffs on 33L.

Concurrent spikes in PBPAH concentrations accompanied PNC spikes during the period of overhead flight activity (Figure S13), i.e., after 1700 hours. High PBPAH concentrations (large sustained changes in concentrations but not transient recurrent spikes) along with an increase in oxides-of-nitrogen species (but not PNC) were also observed during the morning hours of impact-sector winds when flights were not landing overhead (Figure S13-S15). This observation of both the presence and absence of concurrent spikes/elevated concentrations of PBPAH and PNC is worth a further detailed investigation.

Spikes that exceeded daytime concentrations during overhead late evening/nighttime landing hours were not observed in the gaseous pollutants in our dataset. (This is likely an artifact of the combination of lack of fast response and larger averaging time of our measurement

technology and relatively lower signal-to-background ratio for these gaseous pollutants in the plumes; see Figures S13-S16).

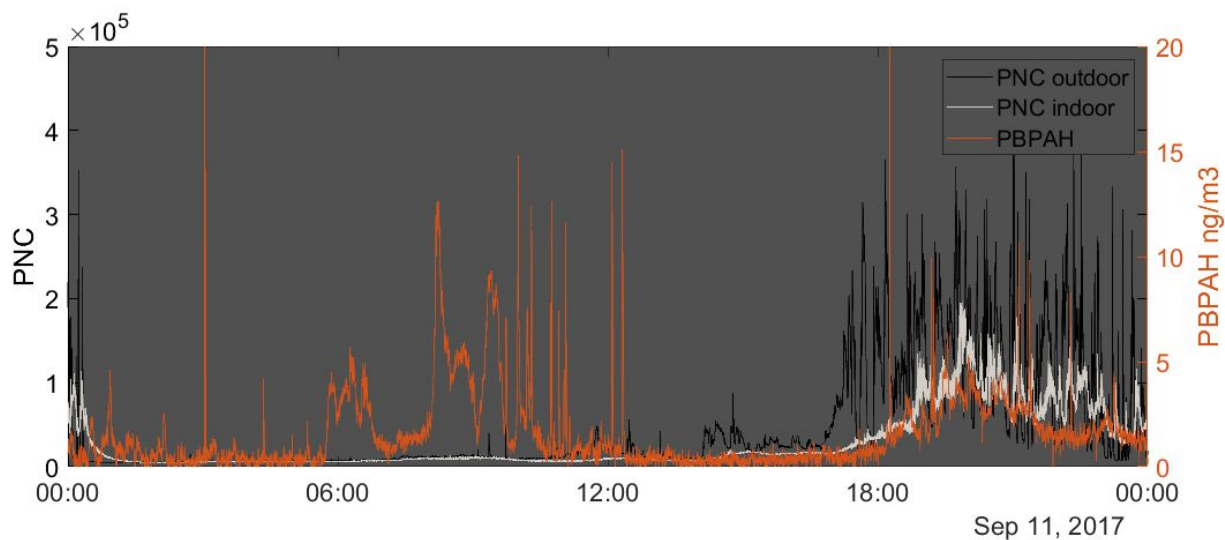


Figure S13: A 24-hour time-series of particle number concentration (PNC) and particle-bound polycyclic aromatic hydrocarbons.

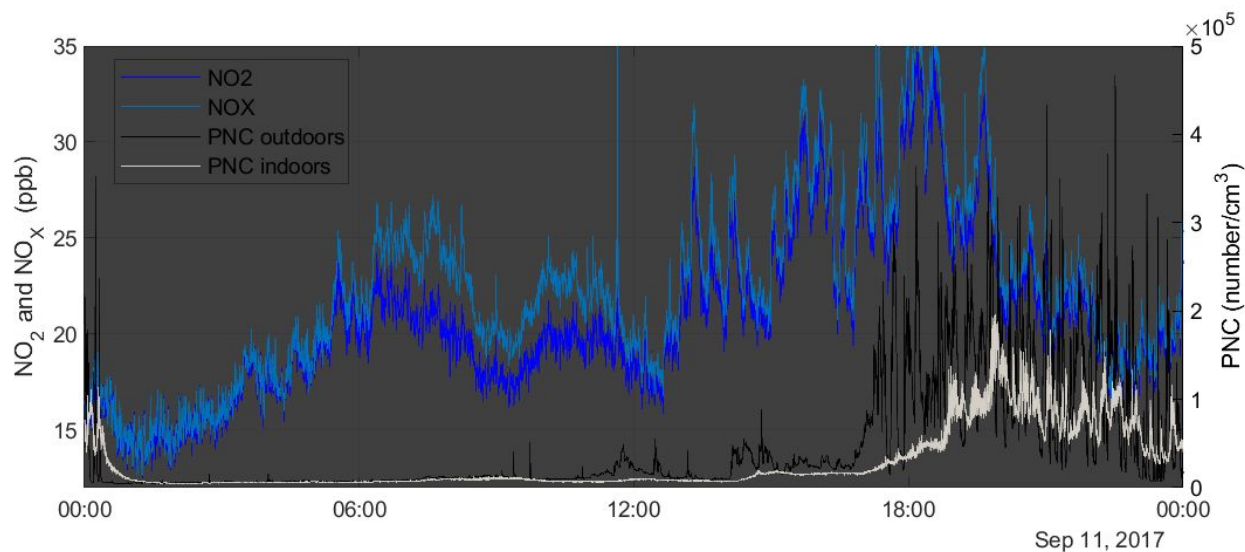


Figure S14: A 24-hour time-series of particle number concentration (PNC) and oxides-of-nitrogen.

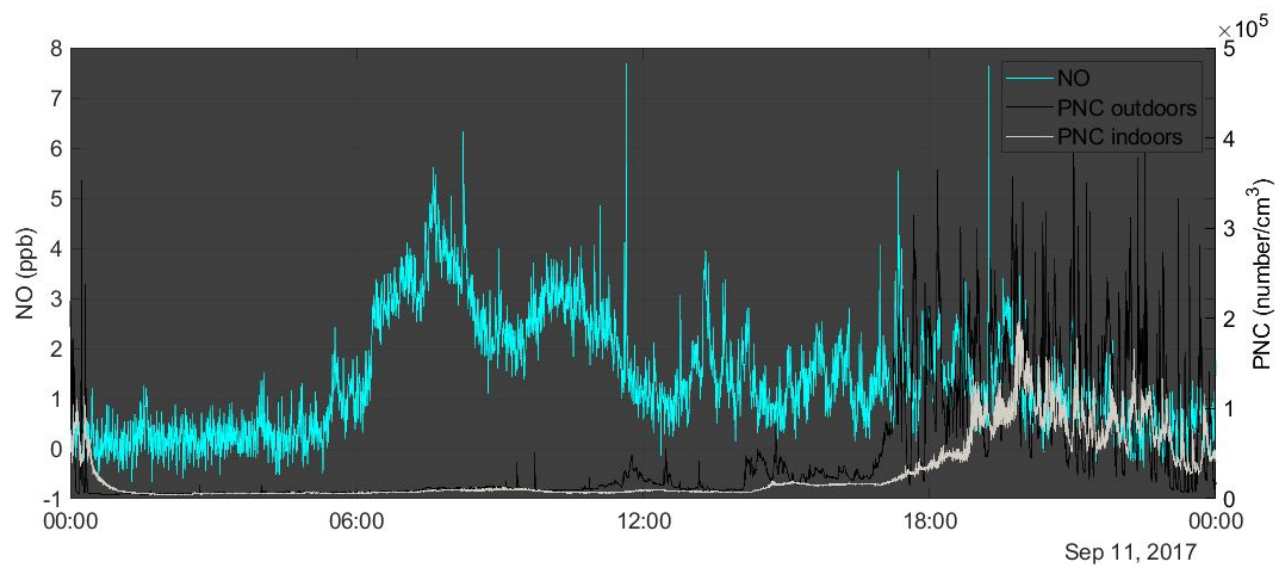


Figure S15: A 24-hour time-series of particle number concentration (PNC) and nitric oxide (NO).

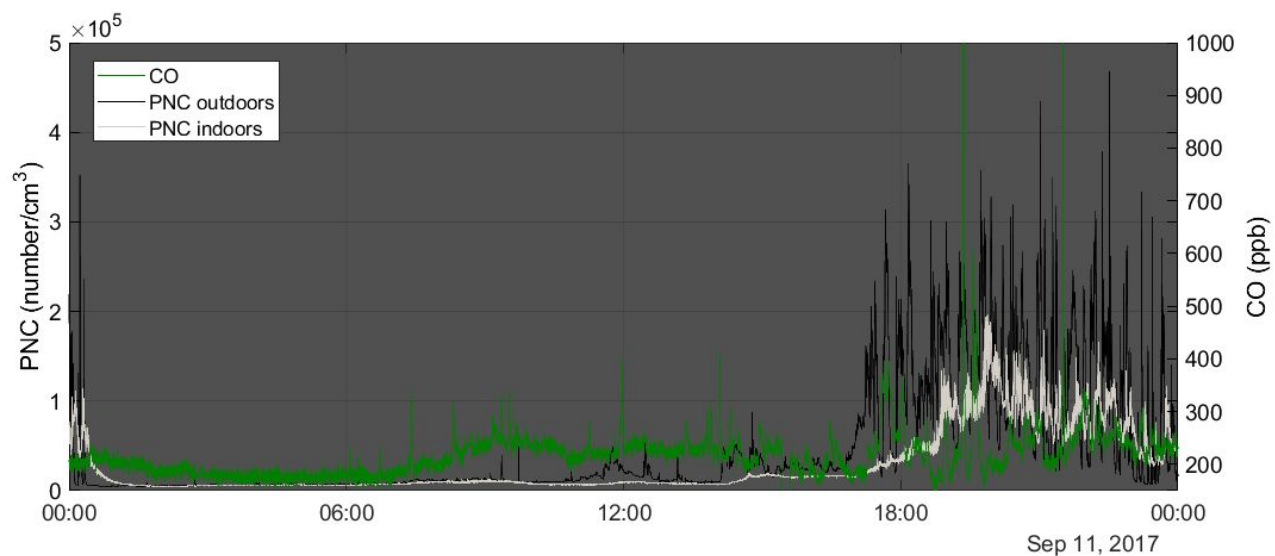


Figure S16: A 24-hour time-series of particle number concentration (PNC) and carbon monoxide (CO).

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Figure S17: (a) Locations of regulatory sites and Tufts UFP monitoring network sites. (b)-(h) Comparison of diurnal patterns for pollutants measured at the regulatory sites to near-airport site. See Table S2 for details on instrumentation used at the regulatory sites.

Figure S17a shows the location of the regulatory sites to which we compared our measurements. These five proximal regulatory monitoring sites are operated by the Massachusetts Department of Environmental Protection (MassDEP)⁹ in Suffolk and Essex counties. For ease of interpretation, we refer to these sites by their distinguishing features as opposed to the names assigned by MassDEP. The sites are as follows: (a) a near-road network site in South Boston (ID: 25-025-0042) on the east shoulder of Interstate I-93N and 6 km SW of the airport in a highly trafficked urban area (we refer to this site as *adjacent-highway*); (b) another near roadway site (ID: 25-025-0002) located in Kenmore Square in Boston at the intersection of five streets and 100 m N from Interstate I-90, and ~6 km W of the airport (*near-roadway*); (c) a site (ID: 25-025-0043) located in downtown Boston 3.5 km W of the airport (*downtown*); (d) a site (ID: 25-025-0044) in Dudley Square located 7.5 km WSW of the airport that is considered indicative of the neighborhood scale (*urban-background*); and (e) a site 13 km NNE of the airport in Lynn, MA (ID: 25-009-2006) that is considered indicative of regional-scale air quality (*regional-background*). Traffic volumes (annual average daily traffic estimated from the regional planning commission¹) in the 1-km area around these sites are shown in Figures S2b-f and instruments used are summarized Table S2.

Comparison of the near-airport and regulatory site measurements for PNC and oxides-of-nitrogen is discussed in the manuscript and other pollutants are discussed in the following paragraph.

CO concentrations at the residence were marginally higher or comparable to averages recorded at the regional and urban background sites but lower than at the adjacent-highway site. The study-duration average CO concentration at the near-airport residence (200 ± 60 ppb overall and 220 ± 50 ppb during impact-sector winds) was comparable to the averages at the regional background site (190 ± 70 ppb) and the urban background site (200 ± 70 ppb), and lower than the 280 ± 110 ppb average at the adjacent-highway site. $PM_{2.5}$ concentrations were comparable to the other sites with no distinct diurnal pattern, which is expected given the generally homogenous spatial distribution of $PM_{2.5}$ in the region. BC concentrations at the near-airport residence were substantially lower than those at three regulatory monitoring sites (at which it was monitored) for all hours of the day. The near-airport residence study-duration average was

330±250 µg/m³ (390±230 µg/m³ during impact-sector winds). This was nearly 2-fold lower than the urban-background site average (630±450 µg/m³) and about 4-fold lower than the downtown site average (1,200±850 µg/m³) and the adjacent-highway site average (1,300±940 µg/m³).

Table S8: Summary of pollutant concentrations measured at regulatory and other sites during the monitoring period.

	near-airport overall, i.e., all winds	near-airport impact-sector winds	adjacent- highway	downtown	near- roadway	urban- background	regional- background	Chelsea
Temperature °C			20 ± 3	21 ± 3	21 ± 3	20 ± 3		
Relative Humidity %			68 ± 19			67 ± 20		
Carbon monoxide ppb	203 ± 57	220 ± 50	294 ± 114			207 ± 81	209 ± 78	
Nitric oxide (NO) ppb	1 ± 2	2 ± 3	9 ± 11		5 ± 6	2 ± 5	0.4 ± 2	
Nitrogen dioxide (NO ₂) ppb	15 ± 6	17 ± 7	11 ± 7		12 ± 8	8 ± 7	3 ± 4	
Oxides of nitrogen (NO _x) ppb	16 ± 7	18 ± 8	20 ± 16		17 ± 13	11 ± 10	3 ± 5	
PM _{2.5} µg/m ³ **	8 ± 4	7 ± 2	7 ± 5	8 ± 5	7 ± 2	8 ± 5	8 ± 8	
Black carbon (BC) ng/m ³	330 ± 250	390 ± 230	1287 ± 942	1157 ± 845		629 ± 468		
PNC particles/cm ³	18000 ± 31000	38000 ± 42000				12,000±5,900*		11,000±9,700

* Data was available for the period August 23-September 09, 2017 for this pollutant at this site. ** An adjustment factor of 0.6 was applied to the PM_{2.5} measurements to account for the difference between the particle densities used to calibrate the instrument versus the typical average composition of particles in the metropolitan Boston area.²

References

- (1) MassGIS. MassGIS Data: Massachusetts Department of Transportation (MassDOT) Roads <https://docs.digital.mass.gov/dataset/massgis-data-massachusetts-department-transportation-massdot-roads#Attributes>.
- (2) Masri, S.; Kang, C. M.; Koutrakis, P. Composition and Sources of Fine and Coarse Particles Collected during 2002–2010 in Boston, MA. *J. Air Waste Manag. Assoc.* **2015**, *65* (3), 287–297. <https://doi.org/10.1080/10962247.2014.982307>.
- (3) Hudda, N.; Simon, M. C.; Zamore, W.; Durant, J. L. Aviation-Related Impacts on Ultrafine Particle Number Concentrations Outside and Inside Residences near an Airport. *Environ. Sci. Technol.* **2018**, *52* (4), 1765–1772. <https://doi.org/10.1021/acs.est.7b05593>.
- (4) Hudda, N.; Simon, M. C. C.; Zamore, W.; Brugge, D.; Durant, J. L. Aviation Emissions Impact Ambient Ultrafine Particle Concentrations in the Greater Boston Area. *Environ. Sci. Technol.* **2016**, *50* (16), 8514–8521. <https://doi.org/10.1021/acs.est.6b01815>.
- (5) Seinfeld, J. H.; Pandis, S. N. *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*; 2006.
- (6) Herndon, S. C.; Jayne, J. T.; Lobo, P.; Onasch, T. B.; Fleming, G.; Hagen, D. E.; Whitefield, P. D.; Miake-Lye, R. C. Commercial Aircraft Engine Emissions Characterization of In-Use Aircraft at Hartsfield-Jackson Atlanta International Airport. *Environ. Sci. Technol.* **2008**, *42*, 1877–1883. <https://doi.org/10.1021/es072029+>.
- (7) Wood, E. C.; Herndon, S. C.; Timko, M. T.; Yelvington, P. E.; Miake-Lye, R. C. Speciation and Chemical Evolution of Nitrogen Oxides in Aircraft Exhaust near Airports. *Environ. Sci. Technol.* **2008**, *42* (6), 1884–1891. <https://doi.org/10.1021/es072050a>.
- (8) Herndon, S. C.; Onasch, T. B.; Frank, B. P.; Marr, L. C.; Jayne, J. T.; Canagaratna, M. R.; Grygas, J.; Lanni, T.; Anderson, B. E.; Worsnop, D.; et al. Particulate Emissions from In-Use Commercial Aircraft. *Aerosol Sci. Technol.* **2005**, *39* (8), 799–809. <https://doi.org/10.1080/02786820500247363>.
- (9) MassDEP. *MassDEP Ambient Air Quality Monitoring Network & Annual Plan | Mass.Gov*; 2019.