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Supplement of

Mobile air quality monitoring and comparison to fixed monitoring sites for instrument performance assessment

Andrew R. Whitehill et al.

Correspondence to: Andrew R. Whitehill (whitehill.andrew@epa.gov)

Section SI-1: Denver mapping spatial details

The overall map of all the driving that was performed in Denver is in Figures S1a and S1b. Figure S1a is a map of all the roads that we mapped. In the map you can see areas with more spatially dense coverage as well as roads that broadly cover the Denver metropolitan area. In the areas with denser coverage, like near selected regulatory stations and other features of interest, the roads were driven regularly while others were driven much less often. The frequency with which specific regions or roads were mapped can be seen in the density plot in Figure S1b, where roads driven less frequently are a faint purple, increasing in intensity with more repeat drives as well as moving from purple to yellow-orange.
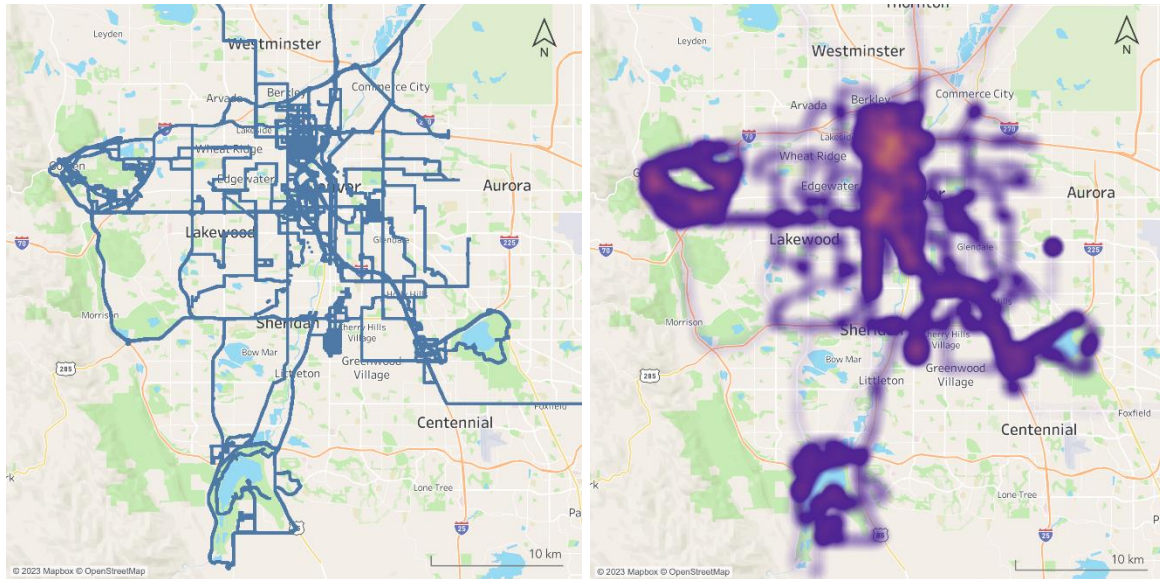

Figure S1: Roads driven during the Denver deployment.

We designed 3 routes in for the La Casa site within a 2.5 km radius of the station: one that maps by driving predominantly north and south through the grid, one that maps by driving predominantly east and west through the grid, and one that maps along a rough spiral from the center out to the edge, as seen in Figure S2. These routes were designed to be driven simultaneously by the 3 cars. One of the routes included a ~ 20 minute collocation as close to the site as was operationally possible. Some days all 3 cars drove the same routes all day long, while on other days the cars either split up to map different areas or mapped one region in the morning and a separate region in the afternoon. No driving routes were designed for the CAMP station; however, the station is ~3.4 km from the La Casa site, and thus the regular driving patterns brought the car to within 1 km of the site on a regular basis.

We aimed to drive each route multiple times at different times of the day and on different days of the week (weekend vs. weekday). Professional drivers drove 8-hour shifts with days having either 1 or 2 shifts. When a single shift operated, it ran from approximately 9 AM to 5 PM. When two shifts operated, the first ran from approximately 5 AM to 1 PM, and the second ran from approximately 2 PM to 10 PM.
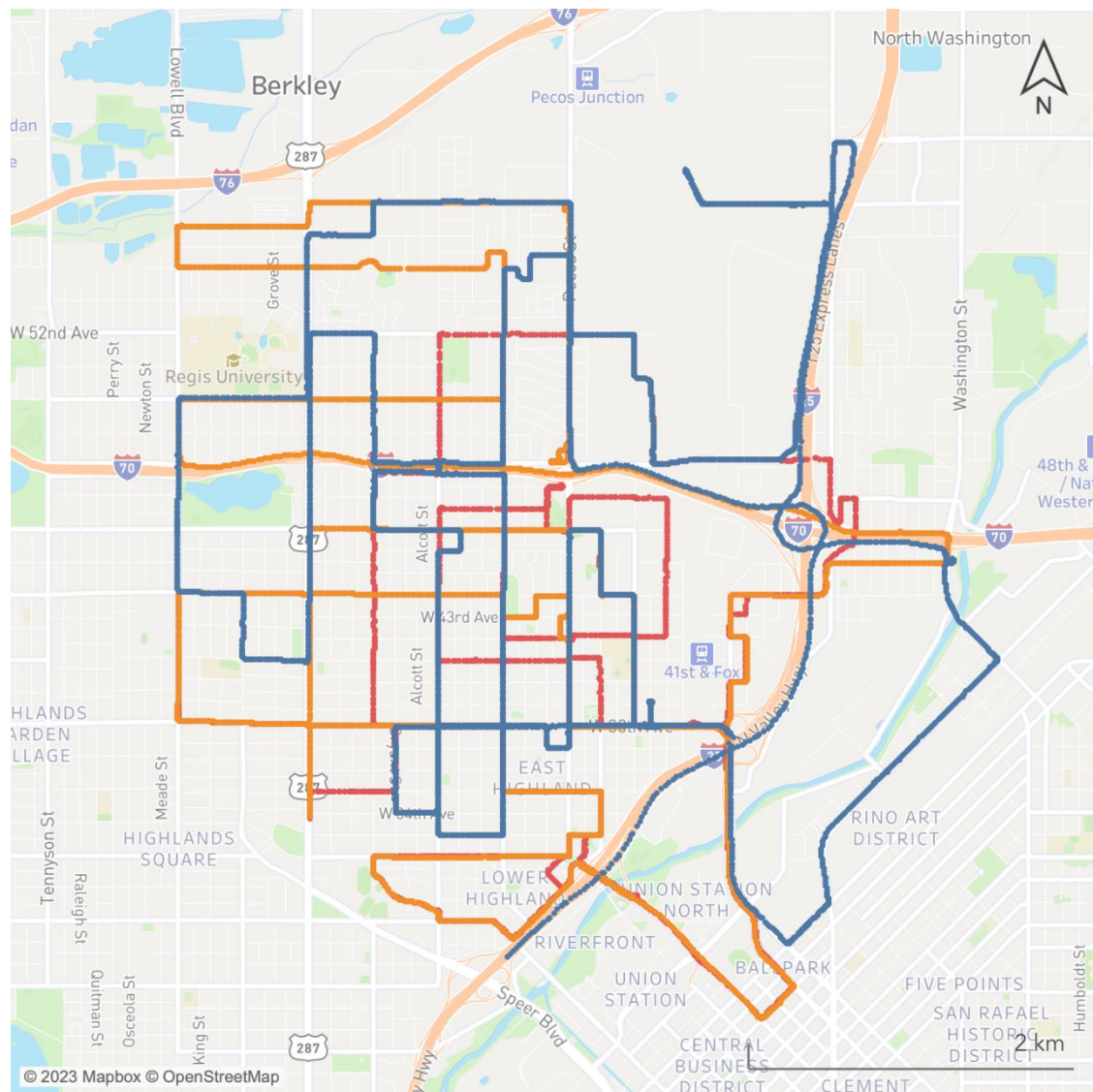
Figure S2: Driving routes around the La Casa regulatory station. The three routes are designated by blue, red, and orange colors.

Figure S3 shows all of the driving performed during the Denver study in relation to its distance from the La Casa site. Circles of radius 500m, 1 km, 3 km, and 5 km centered on the La Casa site are also shown on the map. The figure provides a visual indication of the type of roads included as part of the distance buffer for data used in the mobile collocation analysis. The satellite base map also provides a general impression of the geography and land use in the areas of town near the La Casa site used in the analysis of Section 4.
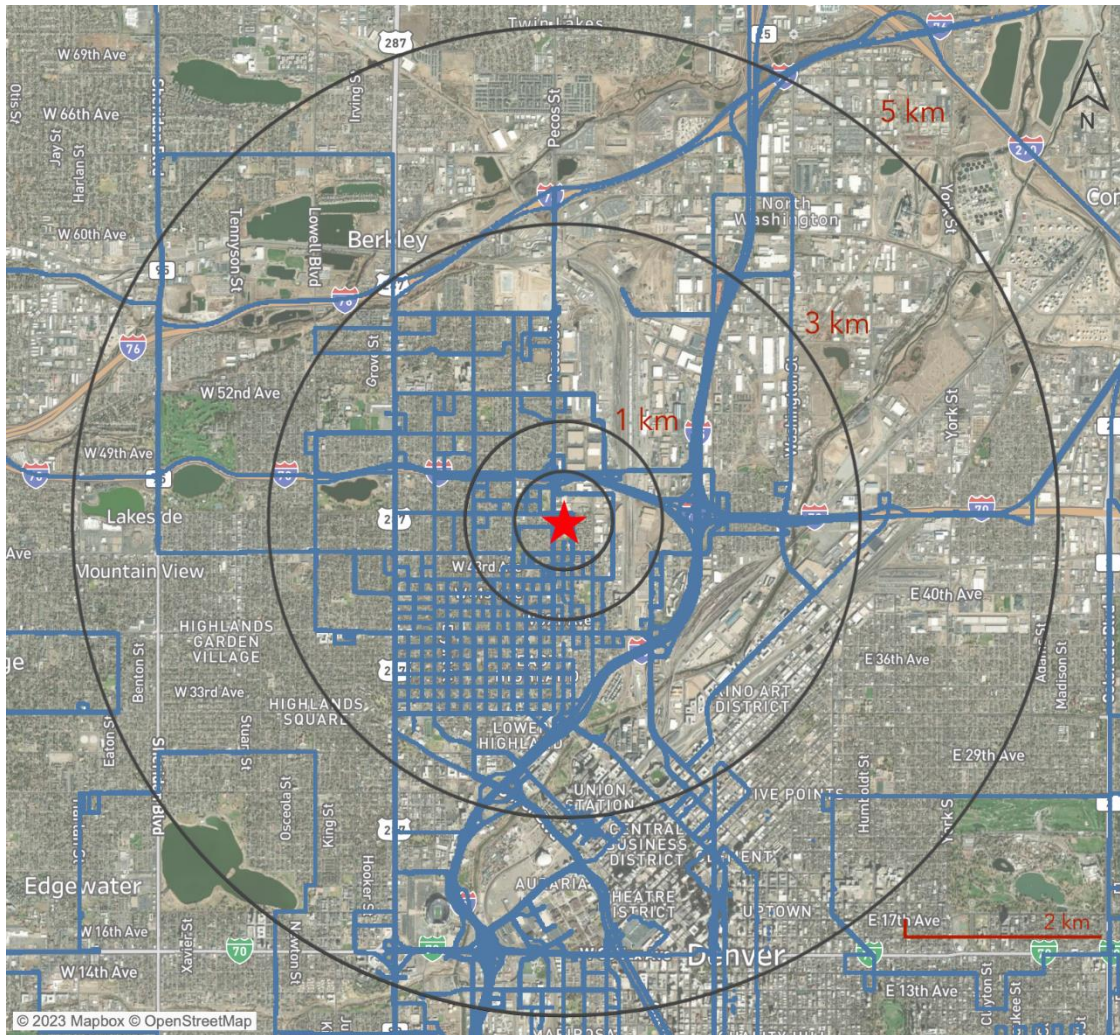
Figure S3: La Casa regulatory site with distance buffers noted at 500km, 1 km, 3 km, and 5 km..

Supplemental Information – Tables

Table S1: Periods when at least one mobile monitoring platform was stationary and collocated with the CAMP site.

Period	Date	Start Time	Duration (minutes)	Car	[1]Distance (m)
1	2014-07-24	13:40	22	Car 1	14
2	2014-07-25	11:59	20	Car 2	84
3	2014-07-30	09:29	21	Car 3	19
4	2014-07-31	09:02	31	Car 2	11
5	2014-07-31	18:33	32	Car 1	26
6	2014-08-01	10:46	20	Car 3	13
7	2014-08-02	09:39	20	Car 1	20
8	2014-08-04	12:42	17	Car 2	13
9	2014-08-05	11:03	21	Car 1	12
10	2014-08-11	16:45	23	Car 1	80
11	2014-08-12	13:11	24	Car 1	17
12	2014-08-12	22:31	19	Car 2	26
13	2014-08-12	22:31	19	Car 3	25
14	2014-08-13	14:12	21	Car 3	39
15	2014-08-14	22:01	20	Car 1	15

[1]Horizontal distance based on GPS coordinates of the site (from the state air monitoring plan) and the car. Estimated uncertainty in distances is ± 5 m.

Table S2: Periods when at least one mobile monitoring platform was stationary and collocated with the La Casa site.

Period	Date	Start Time	Duration (minutes)	Car	[1]Distance (m)
1	2014-07-25	12:31	19	Car 1	129
2	2014-07-28	11:31	28	Car 2	94
3	2014-07-28	16:59	19	Car 3	81
4	2014-07-29	09:16	21	Car 3	85
5	2014-07-29	14:53	19	Car 1	145
6	2014-07-29	15:53	19	Car 3	92
7	2014-07-31	07:17	23	Car 3	84
8	2014-07-31	08:33	19	Car 1	123
9	2014-07-31	11:23	19	Car 1	125
10	2014-07-31	13:25	21	Car 3	82
11	2014-07-31	21:23	20	Car 2	132
12	2014-08-01	00:14	20	Car 2	140
13	2014-08-02	10:10	24	Car 1	94
14	2014-08-02	12:00	21	Car 1	87
15	2014-08-08	20:29	19	Car 3	137
16	2014-08-08	21:37	20	Car 2	112

[1]Horizontal distance based on GPS coordinates of the site (from the state air monitoring plan) and the car. Estimated uncertainty in distances is ± 5 m.

Table S3: Regression statistics for O_3 (ppbv), NO_2 (ppbv), NO (ppbv), and O_x (ppbv) for the parked mobile platform at a fixed reference site (either La Casa or CAMP) during the 2014 Denver study.

	La Casa			CAMP		
	Slope	Intercept	r^2	Slope	Intercept	r^2
O_3						
1 Minute	1.013	-4.12	0.967	0.873	0.51	0.858
Mean	1.020	-4.47	0.988	0.921	-0.91	0.950
Median	1.023	-4.50	0.991	0.960	-2.29	0.960
NO_2						
1 Minute	0.838	2.49	0.596	0.652	8.42	0.399
Mean	0.867	2.12	0.775	0.672	7.78	0.674
Median	0.814	2.78	0.779	0.749	5.82	0.767
NO						
1 Minute	1.164	4.61	0.149	1.099	13.29	0.149
Mean	1.252	4.46	0.442	1.746	6.72	0.445
Median	0.993	3.59	0.405	1.482	7.15	0.341
O_x						
1 Minute	0.932	-0.03	0.828	0.816	7.81	0.708
Mean	0.958	-1.39	0.885	0.893	3.26	0.824
Median	0.932	-0.82	0.918	0.872	4.25	0.839

Table S4: Relationship between OSM road classifications and the road type designations we assigned the segment for the purposes of the current analysis.

Study Road Type	OSM Highway Designation
Highway	motorway
	motorway_link
	trunk
	trunk_link
[1]**Major**	primary
	primary_link
	secondary
	secondary_link
	tertiary
	tertiary_link
[1]**Residential**	living_street
	unclassified
[1]**Other**	service
	unclassified

[1]Major, Residential, and Other roads are also included in the aggregate road class "Non-Highway"
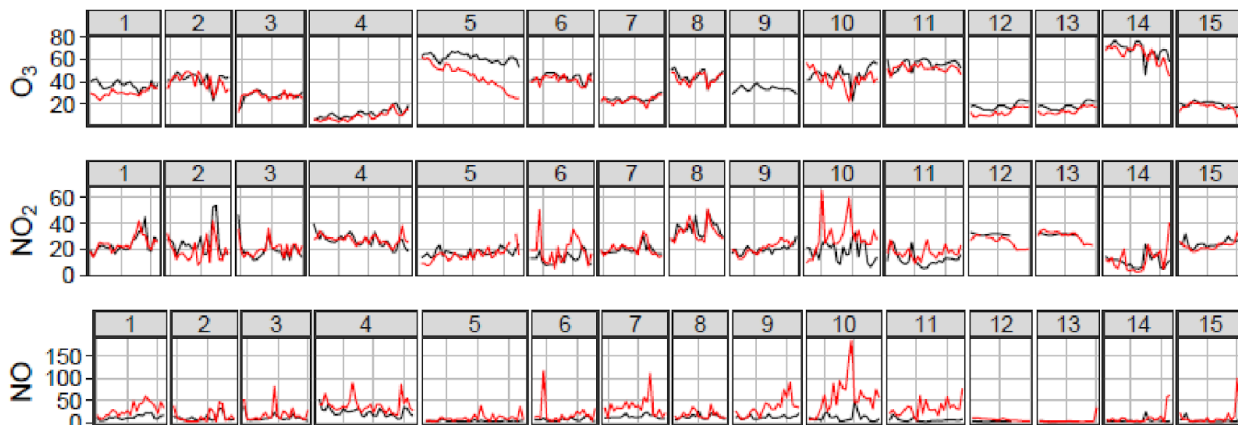
Supplemental Information – Figures

Figure S4: Comparison of one minute average mobile platform measurements (red) and the CAMP site measurements (black) during the stationary collocated periods.
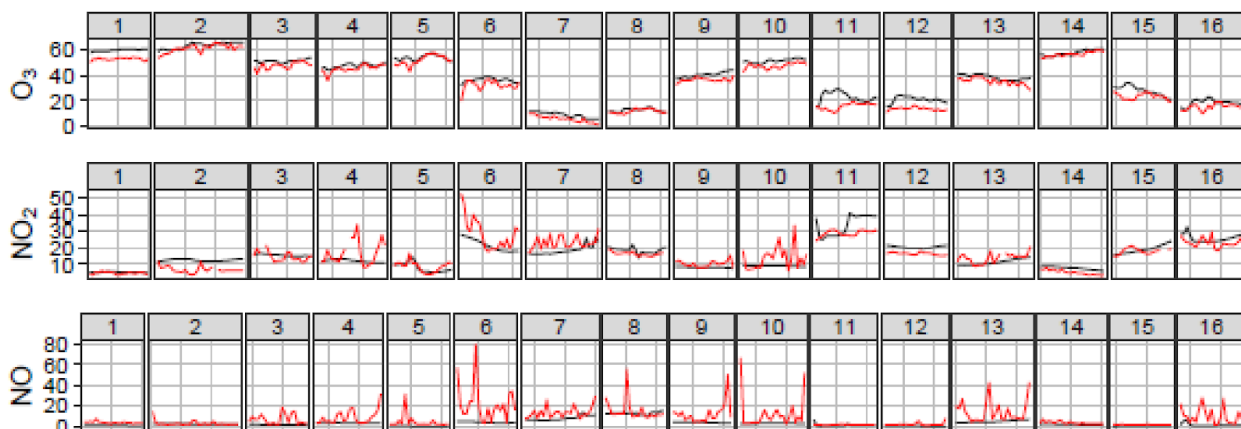

Figure S5: Comparison of one minute average mobile platform measurements (red) and the La Casa site measurements (black) during the stationary collocated periods.
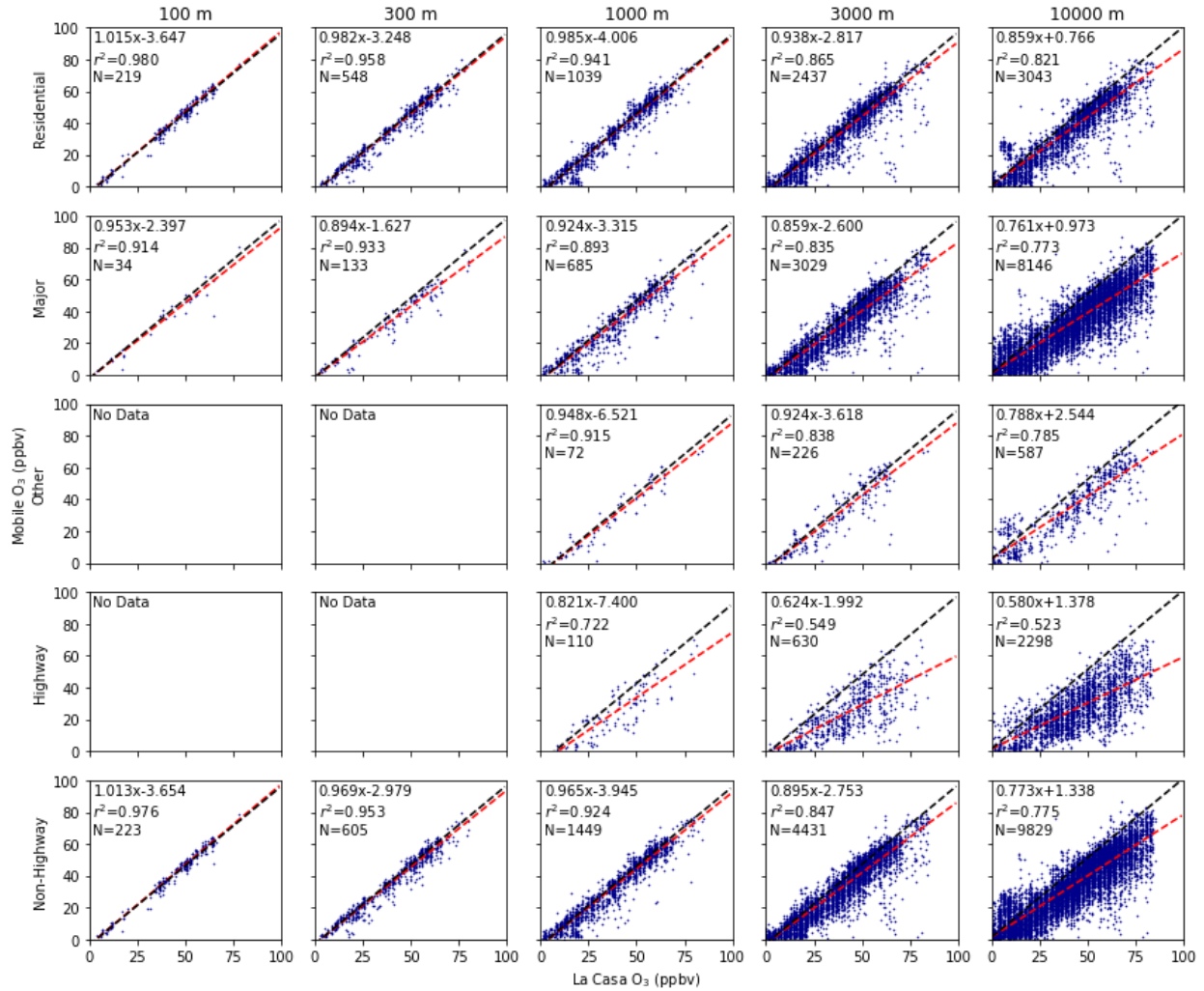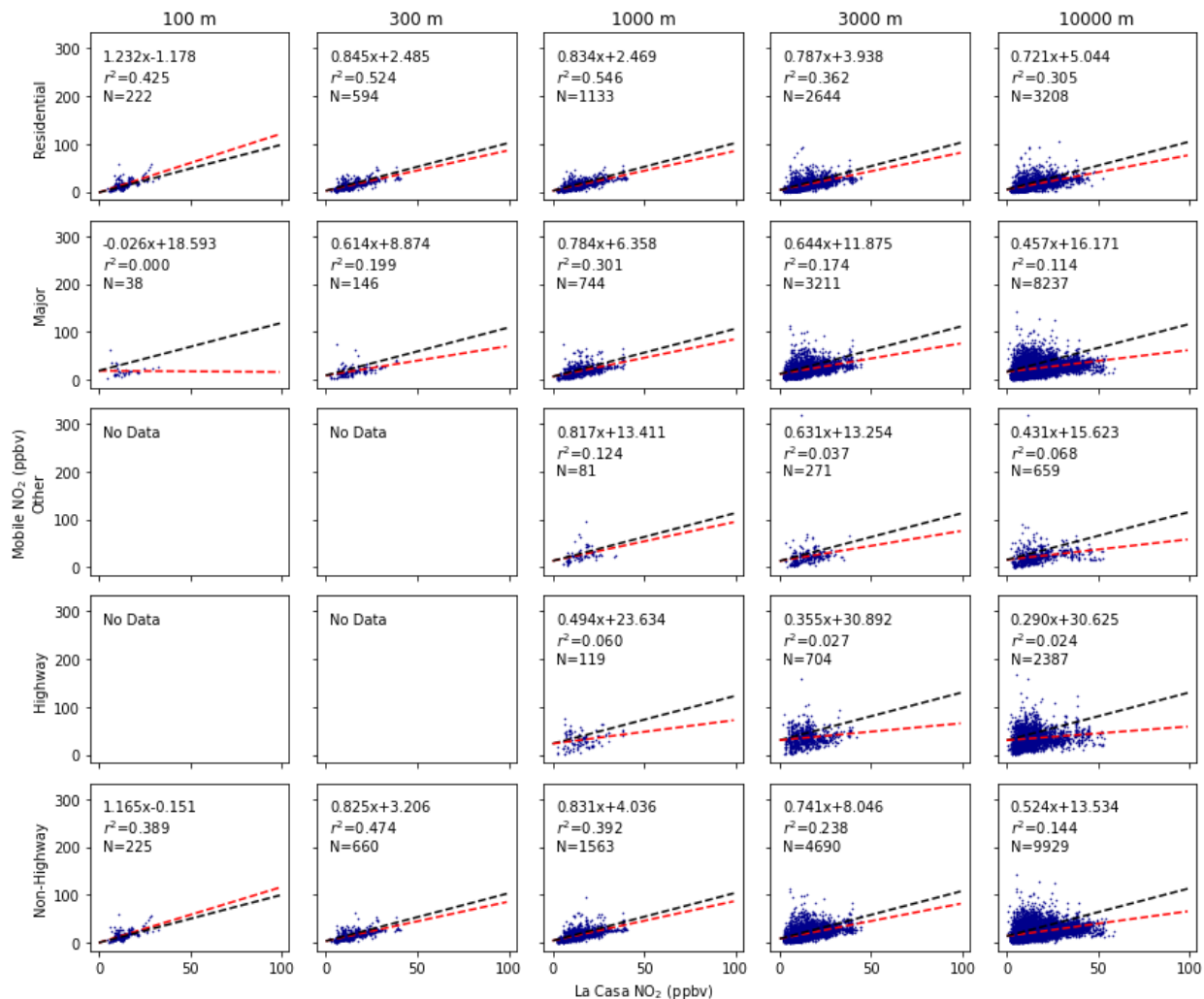
Figure S6: Scatterplots of 1-minute average mobile platform versus 1-minute fixed reference site O_3 for different road classes within five distance buffers of the La Casa site. The red dashed lines show the result of the ordinary least squares regression. The black dashed lines are 1:1 lines. The number of datapoints in the Non-Highway class may be less than the sum of the number of datapoints in the Residential, Major, and Other classes because a car travelling on multiple road classes during the one-minute averaging period could cause a single one-minute period to be counted for multiple different road classes, but is only counted one time in the Non-Highway category.
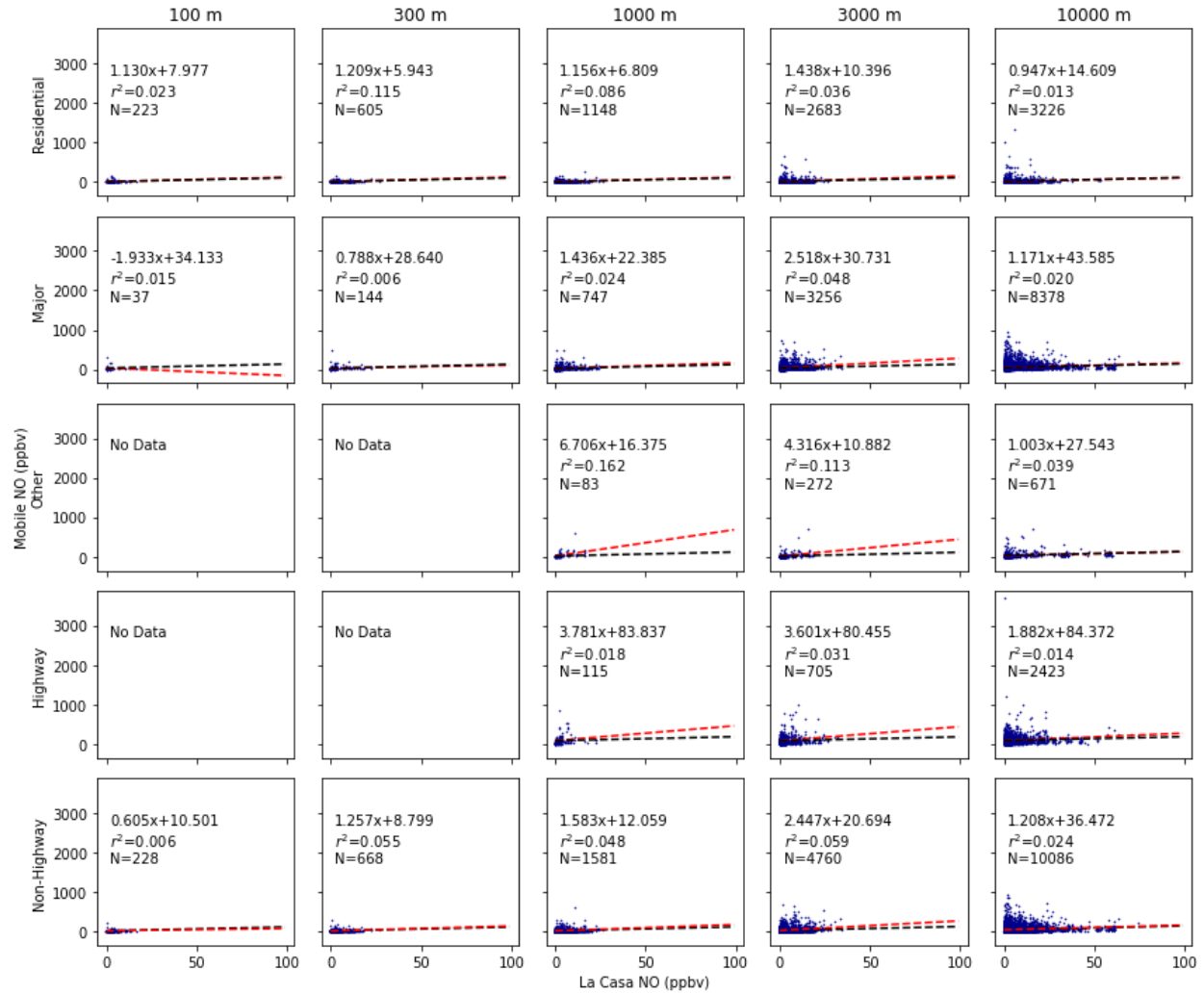
Figure S7: Scatterplots of 1-minute average mobile platform versus 1-minute fixed reference site NO_2 for different road classes within five distance buffers of the La Casa site. The red dashed lines show the result of the ordinary least squares regression. The black dashed lines are 1:1 lines. The number of datapoints in the Non-Highway class may be less than the sum of the number of datapoints in the Residential, Major, and Other classes because a car travelling on multiple road classes during the one-minute averaging period could cause a single one-minute period to be counted for multiple different road classes, but is only counted one time in the Non-Highway category.

Figure S8: Scatterplots of 1-minute average mobile platform versus 1-minute fixed reference site NO for different road classes within five distance buffers of the La Casa site. The red dashed lines show the result of the ordinary least squares regression. The black dashed lines are 1:1 lines. The number of datapoints in the Non-Highway class may be less than the sum of the number of datapoints in the Residential, Major, and Other classes because a car travelling on multiple road classes during the one-minute averaging period could cause a single one-minute period to be counted for multiple different road classes, but is only counted one time in the Non-Highway category.
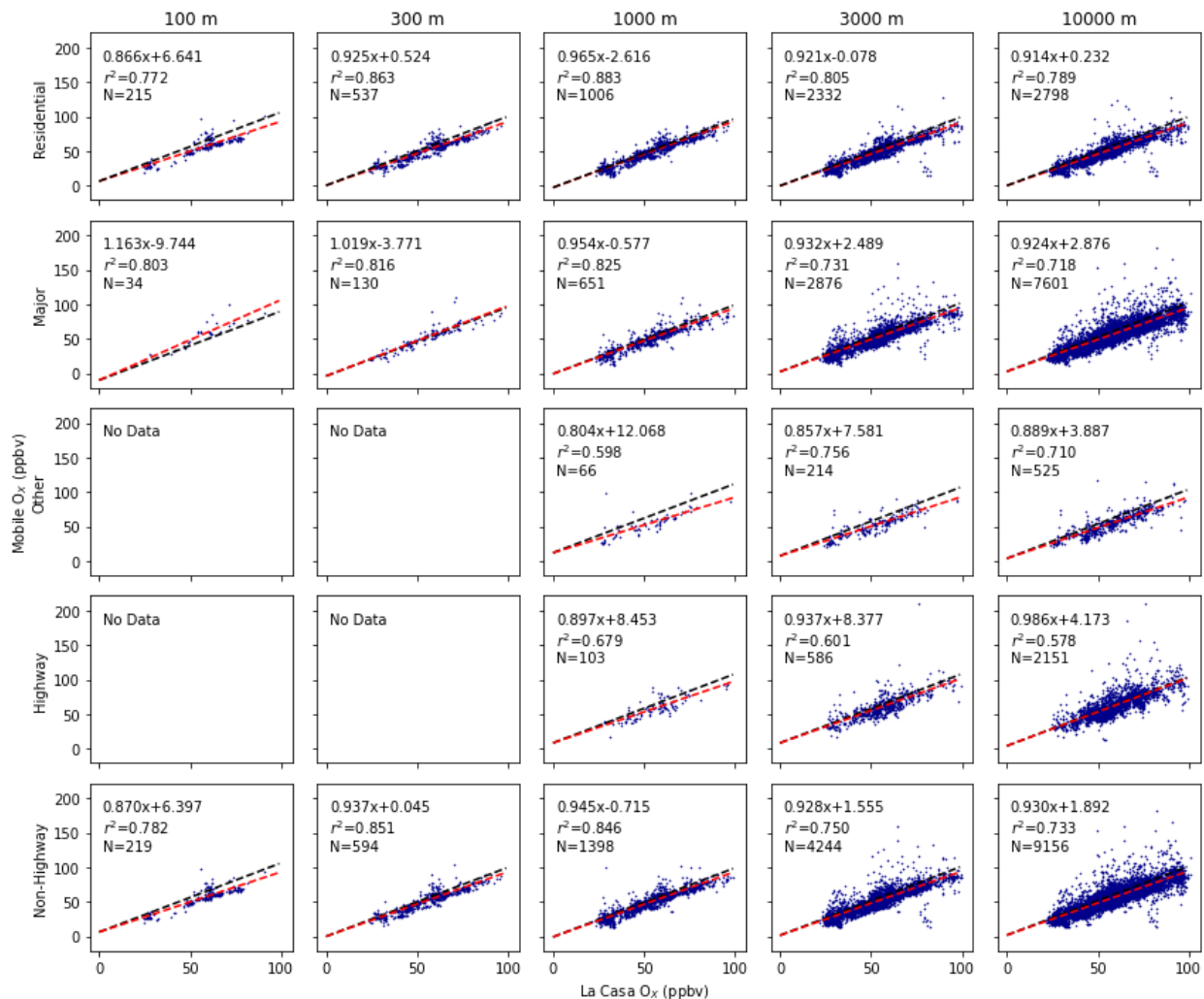
Figure S9: Scatterplots of 1-minute average mobile platform versus 1-minute fixed reference site O_x for different road classes within five distance buffers of the La Casa site. The red dashed lines show the result of the ordinary least squares regression. The black dashed lines are 1:1 lines. The number of datapoints in the Non-Highway class may be less than the sum of the number of datapoints in the Residential, Major, and Other classes because a car travelling on multiple road classes during the one-minute averaging period could cause a single one-minute period to be counted for multiple different road classes, but is only counted one time in the Non-Highway category.
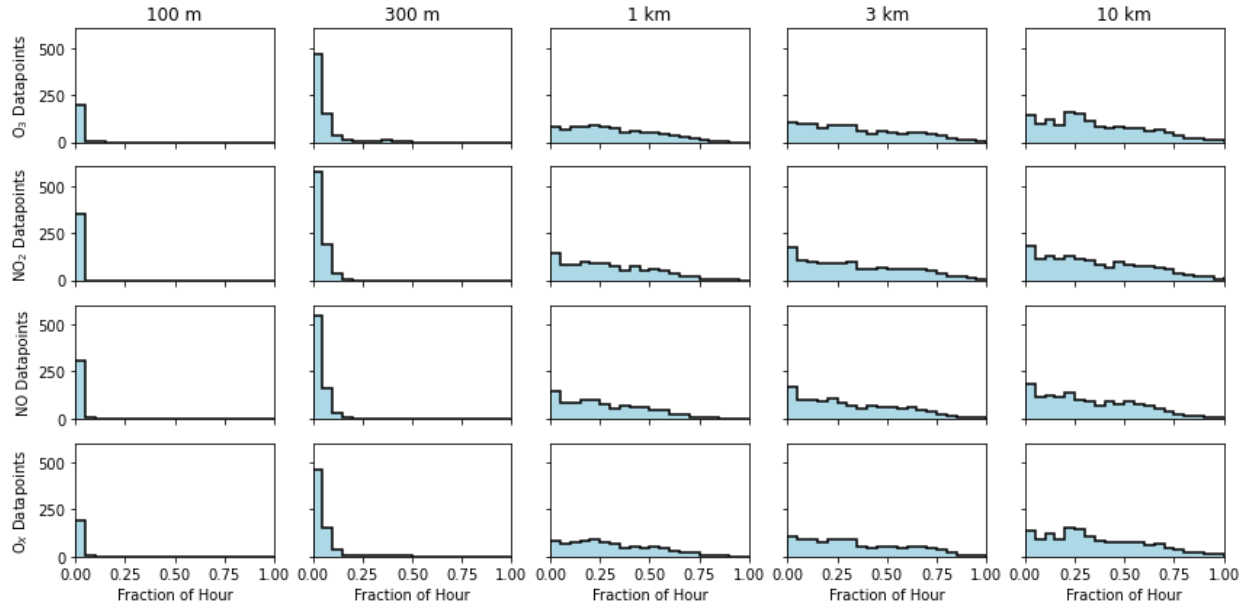
Figure S10: Fraction of each 3600 second period represented by valid 1-second measurements for the Residential subsets of the California dataset (Section 5.1). Each bar spans 0.05 hours (3 minutes).
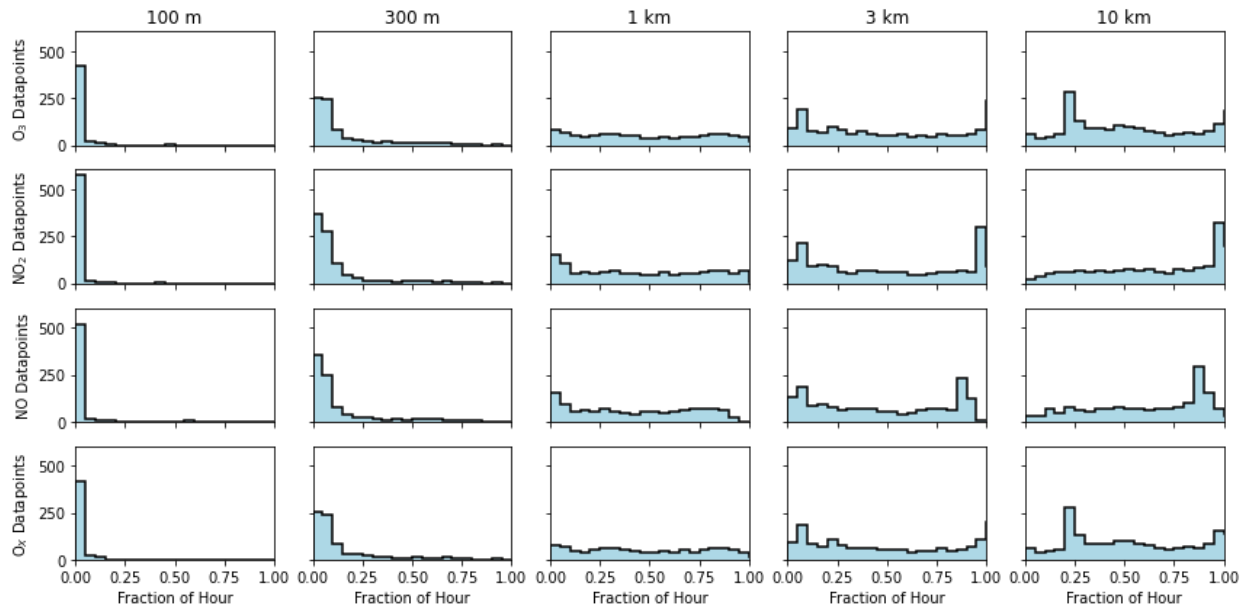

Figure S11: Fraction of each 3600 second period represented by 1-second measurements for the Non Highway subsets of the California dataset (Section 5.1). Each bar spans 0.05 hours.
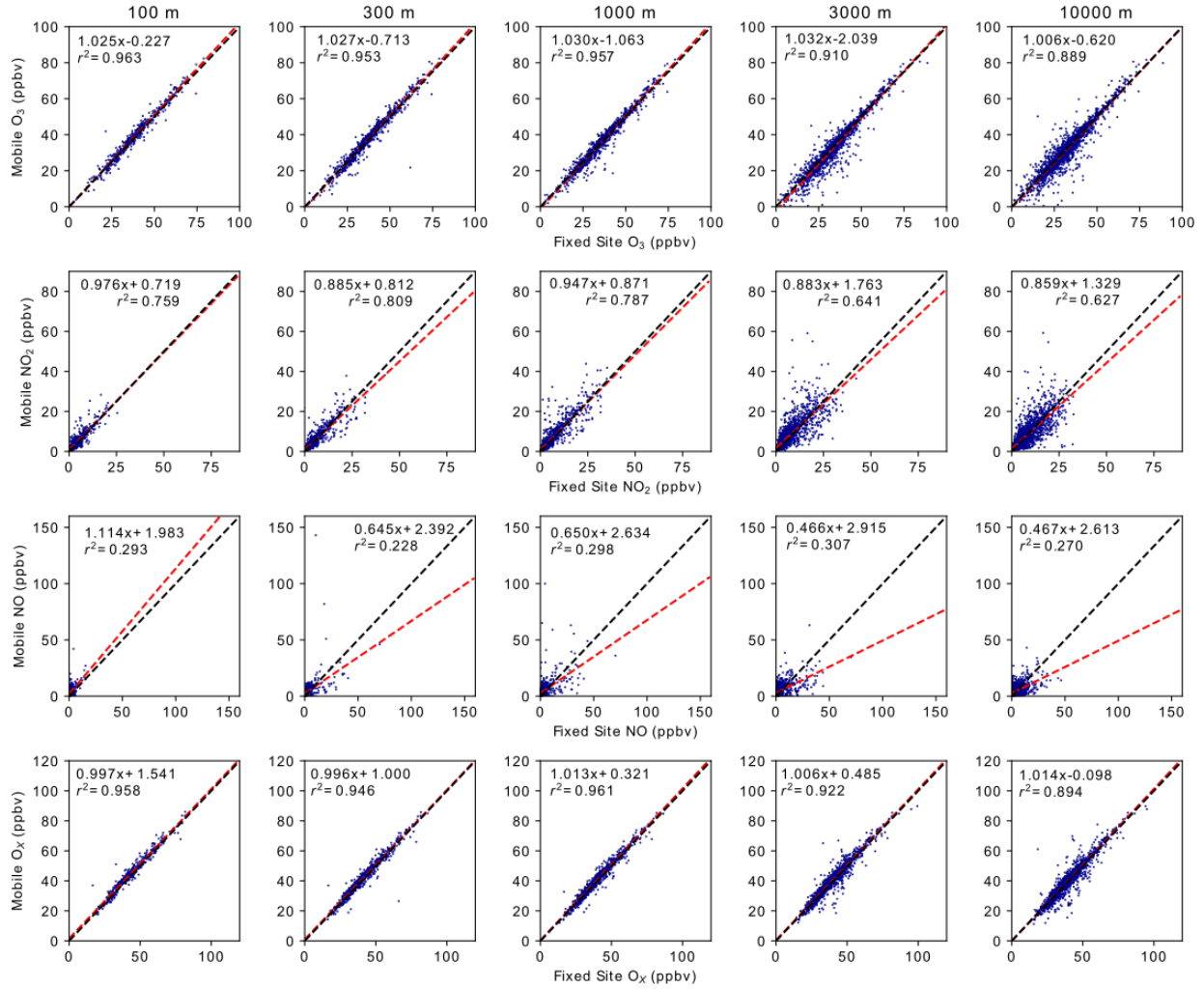
Figure S12: Scatterplots of 1-hour median mobile platform versus 1-hour fixed reference site O_3, NO_2, NO, and O_x for Non-Highway roads within five distance buffers of the fixed reference sites in the California study. Red dashed lines are OLS regression lines, whereas black dashed lines represent 1:1 lines.