sustainability

MDPI

Supplementary Materials

Infiltration of Outdoor $PM_{2.5}$ Pollution into Homes with Evaporative Coolers in Utah County

Darrell B. Sonntag [1], Hanyong Jung [1], Royce P. Harline [1], Tyler C. Peterson [1], Selah E. Willis [2], Taylor R. Christensen [2] and James D. Johnston [2,*]

[1] Department of Civil and Construction Engineering, Brigham Young University, Provo, UT 84602, USA; darrell_sonntag@byu.edu (D.B.S.); jhy22@student.byu.edu (H.J.); royceph@byu.edu (R.P.H.); tylerp22@student.byu.edu (T.C.P.)

[2] Department of Public Health, Brigham Young University, Provo, UT 84602, USA; u1207138@utah.edu (S.E.W.); tchris99@byu.edu (T.R.C.)

* Correspondence: james_johnston@byu.edu; Tel.: +1-801-422-4226

Contents

S.1 Classification of Wildfire Smoke Events

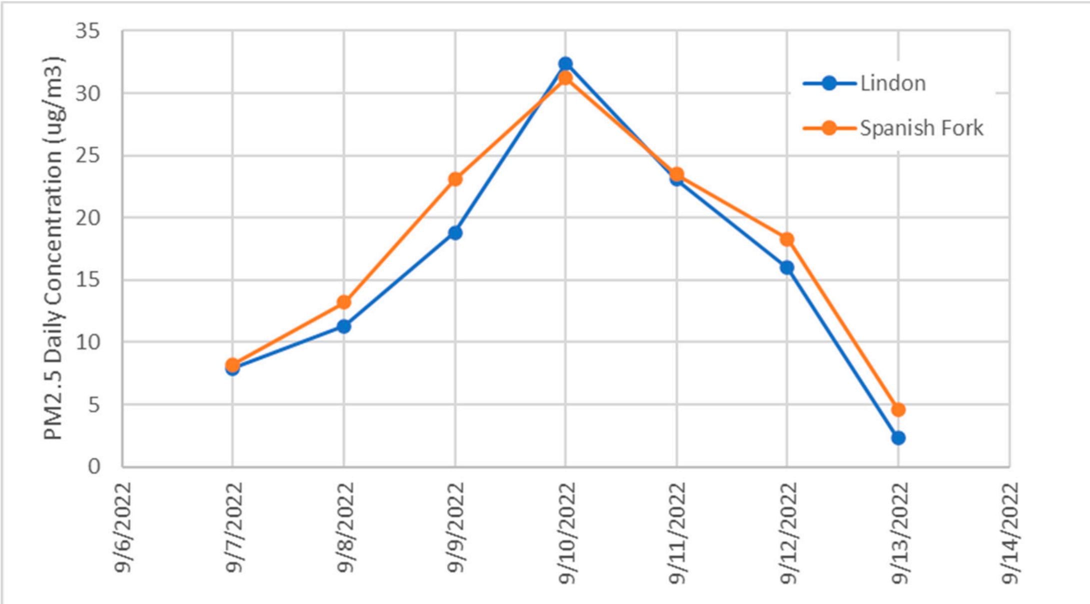

Figure S1. Daily average $PM_{2.5}$ concentrations measured at the Lindon and Spanish Fork primary monitors operated by the Utah Division of Air Quality Monitors in Utah County. Data are obtained from the AirNow Air Quality Network maintained by the US EPA [55]. We used POC 5 for Lindon and POC 3 for Spanish Fork for this graph.

Between 9/8/2022 and 9/12/2022 was the only period where we intentionally scheduled and sampled visits during a known wildfire smoke event. We evaluated if by chance we sampled during other wildfire events. For example, summertime outdoor $PM_{2.5}$ were elevated on 8/3/2022 and 8/14/2023 (Table S3). However, neither of these events had daily $PM_{2.5}$ levels that exceeded 20 $\mu g/m^3$, and we did not classify them as wildfire smoke events.

S.2 Removal of Incomplete Data

We required that each home visit had corresponding indoor and outdoor SidePak concentrations for at least 4 hours. Due to instrument failure (often due to the SidePaks turning off prematurely from lack of AC power) this criterion reduced the number of home visits from 67 from 31 homes down to 53 visits from 30 homes (H27 was removed).

S.3 Inspection of minute-by-minute SidePak $PM_{2.5}$ data

For each home visit, we visually evaluated the minute-by-minute indoor and outdoor concentrations (Figures S2, S3, and S4). For eight of the home visits, the indoor $PM_{2.5}$ concentrations were noticeably elevated above the outdoor concentrations for at least one hour (Table S1). These included visits in homes with AC and ECs and in both summer and winter. We suspect that these high indoor events are likely due to participants not following the study protocol, especially cooking. We removed these events from the final dataset.

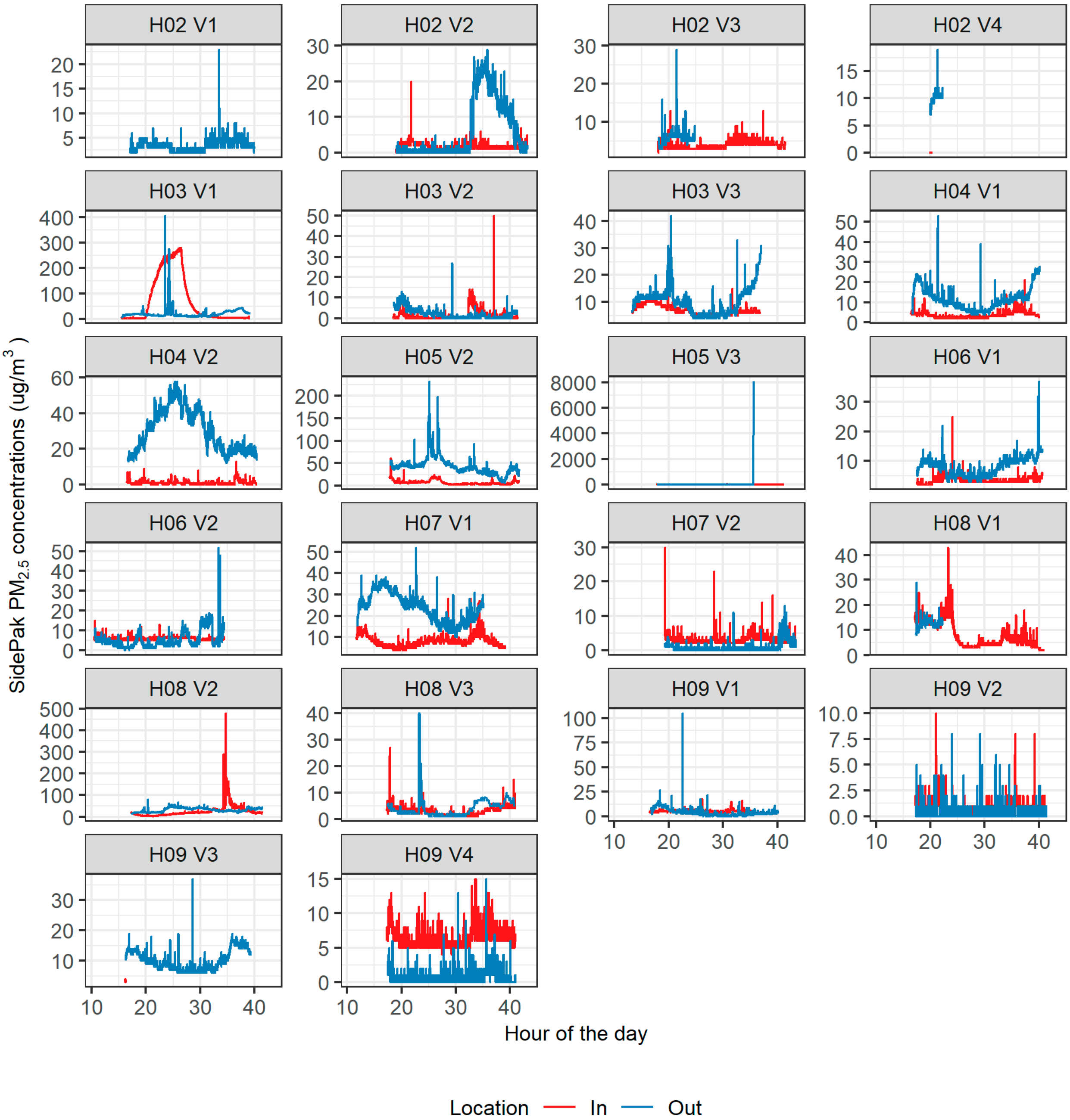

Figure S2. Minute-by-minute SidePak $PM_{2.5}$ concentration measurements from indoor and outdoor visits at homes H02 through H09.

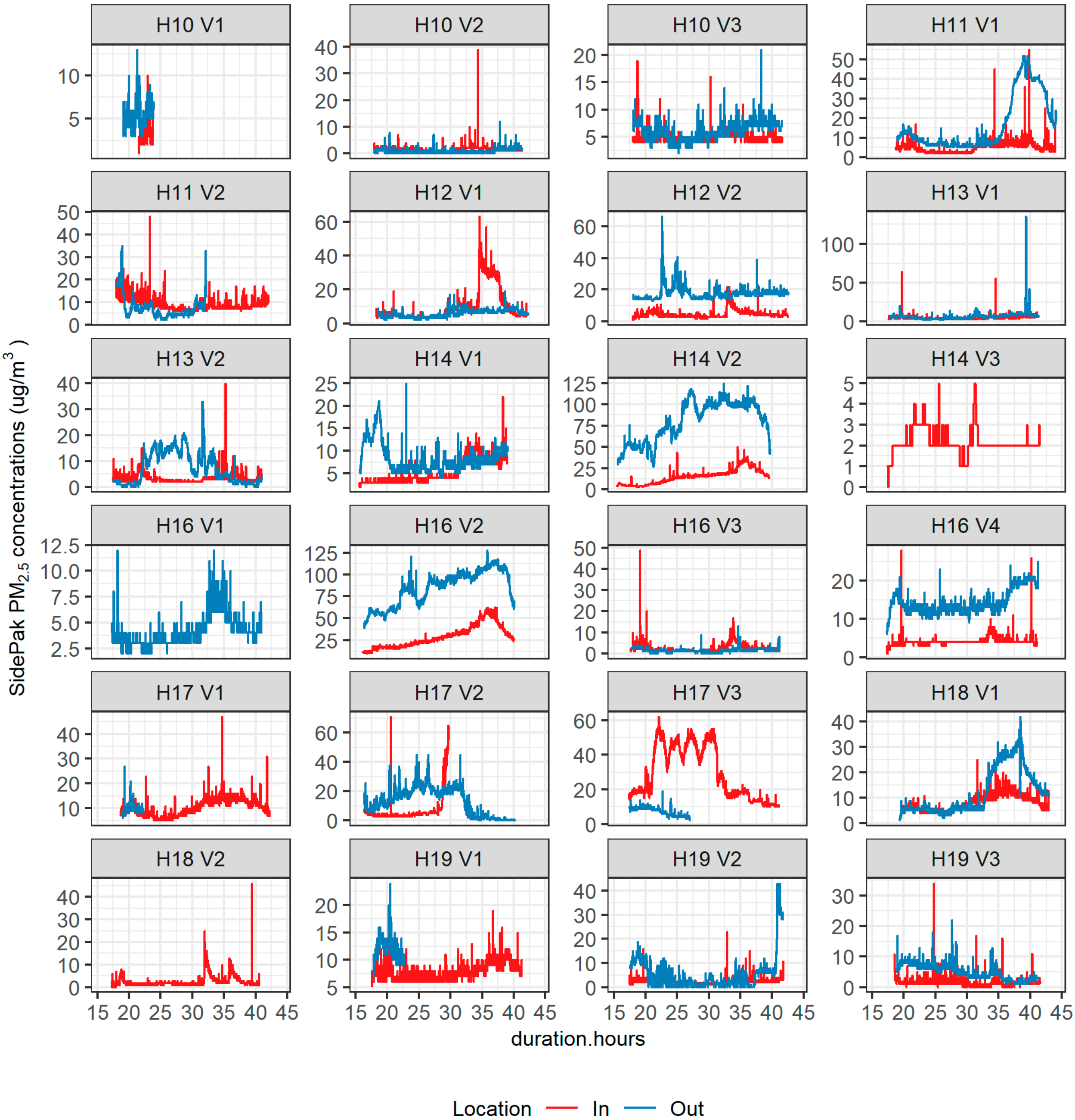

Figure S3. Minute-by-minute SidePak PM2.5 concentration measurements from indoor and outdoor visits at homes H10 through H19.

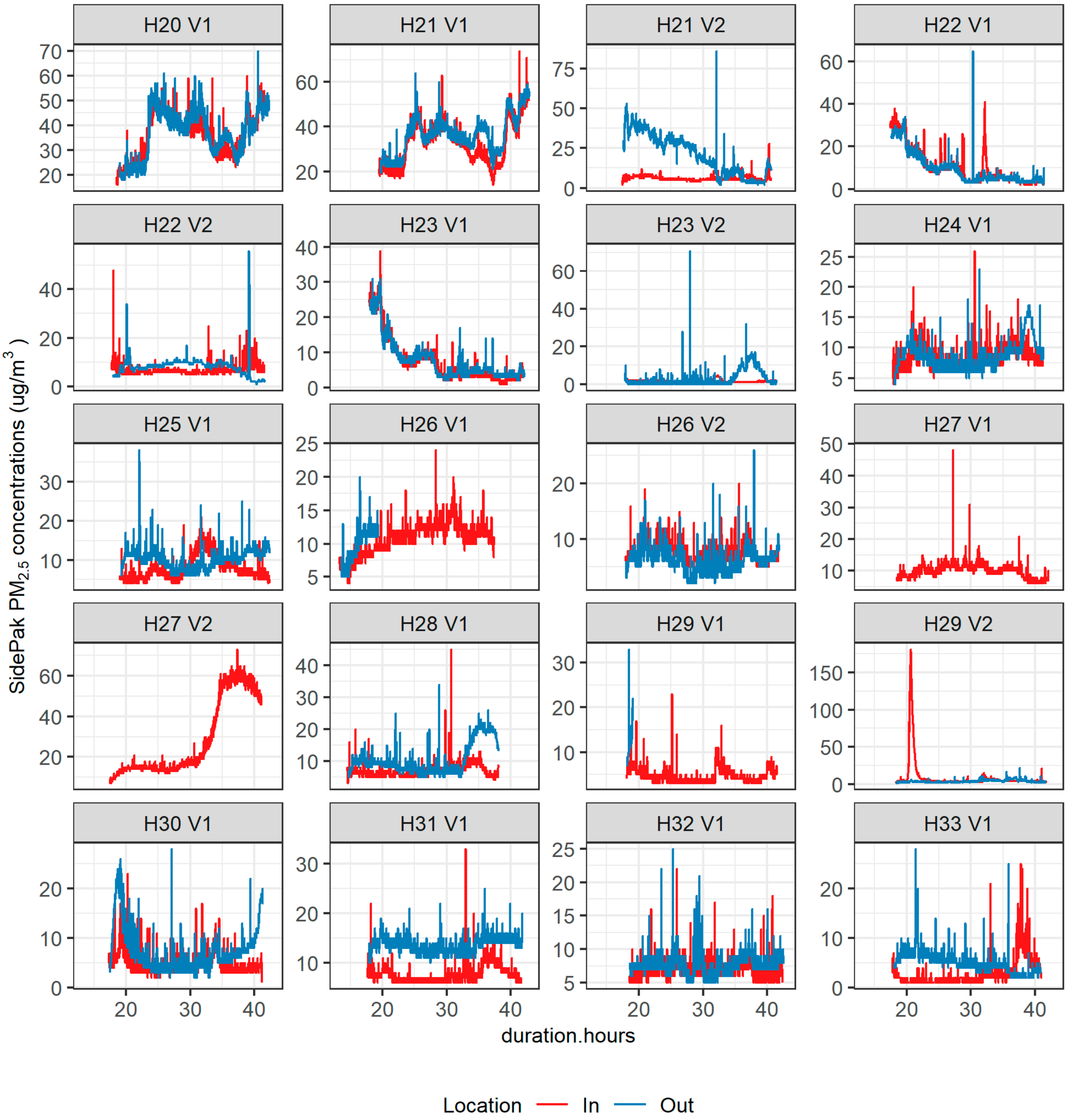

Figure S4. Minute-by-minute SidePak $PM_{2.5}$ concentration measurements from indoor and outdoor visits at homes H20 through H33.

Table S1. Indoor SidePak $PM_{2.5}$ measures suspected as being caused by participants not following the study protocol, especially cooking. We removed these events from the final dataset.

House ID	Type of Air Conditioner	Visit	Beginning time	End Time
H03	Central	V1	2022-07-27 19:54:00	2022-07-28 11:20:00
H03	Central	V2	2022-12-09 08:19:00	2022-12-09 11:01:00
H08	Central	V2	2022-09-09 10:15:00	2022-09-09 14:03:00
H10	Central	V2	2022-12-01 07:45:00	2022-12-01 09:55:00
H12	Central	V1	2022-08-12 10:30:00	2022-08-12 14:34:00
H17	Evaporative Cooler	V2	2023-01-28 04:06:00	2023-01-28 05:43:00
H29	Evaporative Cooler	V2	2023-08-21 20:10:00	2023-08-21 23:16:00
H33	Central	V1	2023-09-01 13:02:00	2023-09-01 16:36:00

S.4 Comparison of $PM_{2.5}$ measurements from the SidePak to the Utah Division of Air Quality (UDAQ) monitors

We obtained hourly $PM_{2.5}$ measurements data from two air quality monitors operated by the Utah Division of Air Quality in Utah County using data from the AirNow API website [56].

Table S2. Utah Division of Air Quality Locations in Utah County

Location	Primary Monitor	Latitude	Longitude
Lindon	1	40.3414	-111.7136
Spanish Fork	3	40.136398	-111.660202

For each home, we determined the closest of the two UDAQ air quality monitors in Utah County [57]. For each visit, we averaged across the hourly $PM_{2.5}$ concentrations from the reference monitors for the same time period that we conducted samples at the home with the SidePak.

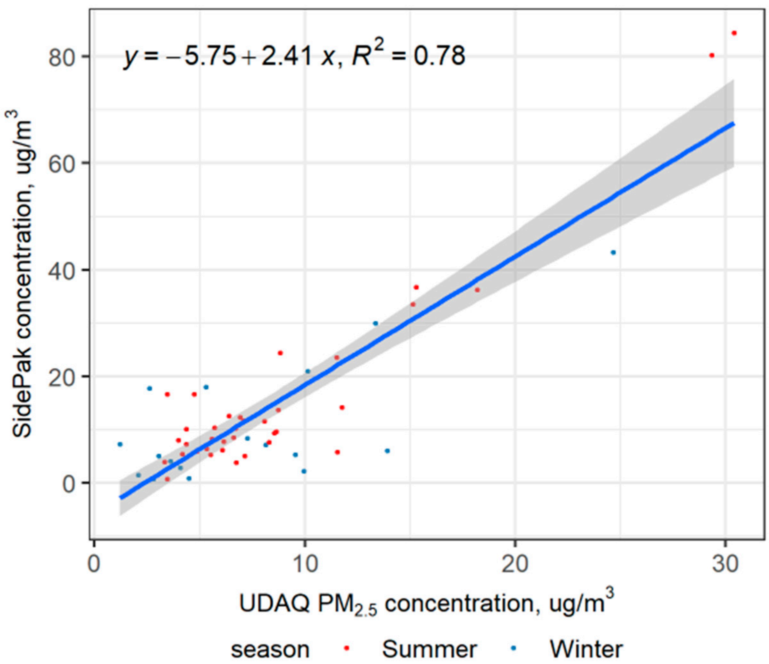

Figure S5. Comparison of the average $PM_{2.5}$ concentrations measured from the outdoor SidePak monitor and closest Utah Division of Air Quality (UDAQ) monitor for each home visit.

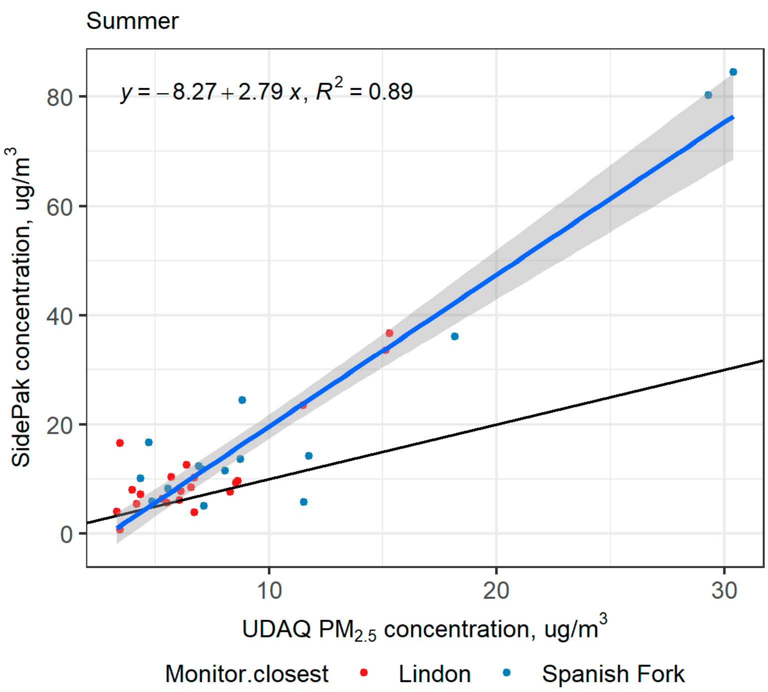

Figure S6. Comparison of the average $PM_{2.5}$ concentrations during summer measured from the outdoor SidePak monitor and closest Utah Division of Air Quality (UDAQ) monitor for each home visit.

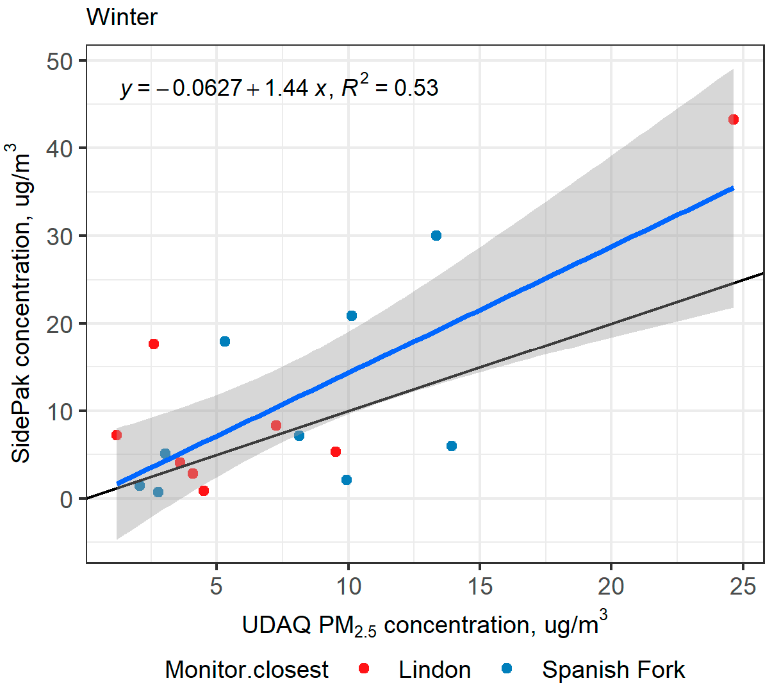

Figure S7. Comparison of the average $PM_{2.5}$ concentrations during winter measured from the outdoor SidePak monitor and closest Utah Division of Air Quality (UDAQ) monitor for each home visit.

S.5 Evaluation of Indoor /Outdoor $PM_{2.5}$ Ratios

We calculated the I/O SidePak $PM_{2.5}$ concentrations for each visit (Tables S7 and S8). We observed three large I/O outliers from visits that had low indoor $PM_{2.5}$ concentrations, but extremely low outdoor concentrations (< 1 μg/m3). These visits included one visit in the summer (Home 09 V4), and two visits in the winter (Home 07 V2, and H10 V2). Home 09 V4 occurred on August 21 and 22, 2023, when Provo also received 0.25 inches of rain [58]. The average outdoor concentration for this visit was only 18% of the outdoor $PM_{2.5}$ concentration for the closest reference monitor. Home 07 V2 and H10 V2 occurred on March 9, 2023 and November 30, 2022, respectively. The outdoor SidePak concentrations were 19% and 24% of the nearest reference monitor $PM_{2.5}$ concentrations.

Table S3. Average indoor and outdoor SidePak concentrations and comparison to the reference monitor for visits from houses with central air conditioning.

House Number	Visit	Date	Indoor SidePak $PM_{2.5}$ (μg/m³)	Outdoor SidePak $PM_{2.5}$ (μg/m³)	I/O	Reference Monitor Location	Reference Monitor $PM_{2.5}$ (μg/m³)	Ratio of Outdoor SidePak to Reference Monitor Concentration
H03	V1	7/27/2022	2.65	24.45	0.11	Spanish Fork	8.82	2.77
H04	V1	7/28/2022	3.67	11.56	0.32	Spanish Fork	8.07	1.43
H06	V1	8/1/2022	3.48	7.93	0.44	Lindon	3.99	1.99
H07	V1	8/3/2022	8.09	23.51	0.34	Lindon	11.50	2.04
H08	V1	8/9/2022	13.67	12.55	1.09	Lindon	6.38	1.97
H09	V1	8/9/2022	4.81	3.83	1.26	Lindon	6.73	0.57
H13	V1	8/10/2022	4.80	6.32	0.76	Lindon	5.32	1.19
H12	V1	8/11/2022	5.97	5.28	1.13	Lindon	5.51	0.96
H14	V1	8/15/2022	5.26	8.27	0.64	Spanish Fork	5.56	1.49
H11	V1	8/16/2022	5.04	16.63	0.30	Spanish Fork	4.72	3.53
H08	V2	9/8/2022	16.90	33.52	0.50	Lindon	15.14	2.21
H14	V2	9/9/2022	15.36	80.31	0.19	Spanish Fork	29.32	2.74
H16	V2	9/9/2022	29.15	84.50	0.34	Spanish Fork	30.39	2.78
H11	V2	11/16/2022	9.31	7.12	1.31	Spanish Fork	8.12	0.88
H06	V2	11/17/2022	5.92	5.30	1.12	Lindon	9.53	0.56
H02	V2	11/21/2022	1.71	5.97	0.29	Spanish Fork	13.92	0.43
H10	V2	11/30/2022	1.36	0.70	1.93	Spanish Fork	2.79	0.25
H03	V2	12/8/2022	0.58	2.13	0.27	Spanish Fork	9.94	0.21
H04	V2	1/25/2023	1.03	29.99	0.03	Spanish Fork	13.33	2.25
H05	V2	2/2/2023	7.53	43.28	0.17	Lindon	24.63	1.76
H07	V2	3/9/2023	3.07	0.83	3.71	Lindon	4.50	0.18
H12	V2	3/27/2023	4.67	17.67	0.26	Lindon	2.61	6.76
H16	V3	3/30/2023	2.36	1.40	1.68	Spanish Fork	2.08	0.68
H13	V2	4/4/2023	3.20	7.20	0.44	Lindon	1.20	6.00
H08	V3	4/13/2023	2.94	4.09	0.72	Lindon	3.60	1.13
H03	V3	8/3/2023	6.98	10.07	0.69	Spanish Fork	4.35	2.32
H10	V3	8/3/2023	4.79	5.89	0.81	Spanish Fork	4.85	1.21
H16	V4	8/14/2023	4.13	14.17	0.29	Spanish Fork	11.76	1.20
H02	V3	8/15/2023	3.28	5.81	0.56	Spanish Fork	11.52	0.50
H05	V3	8/21/2023	6.22	16.57	0.38	Lindon	3.45	4.80
H09	V4	8/21/2023	6.41	0.67	9.53	Lindon	3.45	0.19
H31	V1	8/24/2023	7.52	13.65	0.55	Spanish Fork	8.73	1.56
H33	V1	8/31/2023	1.81	5.44	0.33	Lindon	4.18	1.30

Table S4. Average indoor and outdoor SidePak concentrations and comparison to the reference monitor for visits from houses with evaporative coolers.

House Number	Visit	Date	Indoor SidePak $PM_{2.5}$ (μg/m³)	Outdoor SidePak $PM_{2.5}$ (μg/m³)	I/O	Reference Monitor Location	Reference Monitor $PM_{2.5}$ (μg/m³)	Ratio of Outdoor SidePak to Reference Monitor Concentration
H18	V1	9/1/2022	7.91	12.27	0.64	Spanish Fork	6.91	1.78
H19	V1	9/2/2022	7.25	11.70	0.62	Spanish Fork	7.08	1.65
H20	V1	9/8/2022	36.07	36.72	0.98	Lindon	15.29	2.40
H21	V1	9/8/2022	32.58	36.20	0.90	Spanish Fork	18.18	1.99
H22	V1	9/12/2022	10.02	9.31	1.08	Lindon	8.55	1.09
H23	V1	9/12/2022	7.17	7.63	0.94	Lindon	8.29	0.92
H21	V2	12/8/2022	5.85	20.91	0.28	Spanish Fork	10.14	2.06
H17	V2	1/27/2023	4.33	17.96	0.24	Spanish Fork	5.30	3.39
H19	V2	2/10/2023	2.44	5.08	0.48	Spanish Fork	3.05	1.67
H22	V2	3/3/2023	6.89	8.32	0.83	Lindon	7.25	1.15
H23	V2	4/6/2023	1.57	2.85	0.55	Lindon	4.09	0.70
H24	V1	7/13/2023	8.22	8.51	0.97	Lindon	6.59	1.29
H25	V1	7/13/2023	7.78	10.16	0.77	Lindon	6.71	1.51
H26	V1	7/20/2023	7.63	9.62	0.79	Lindon	8.62	1.12
H28	V1	7/27/2023	6.83	10.35	0.66	Lindon	5.70	1.82
H30	V1	8/10/2023	4.70	7.18	0.65	Lindon	4.36	1.65
H29	V2	8/21/2023	4.18	3.95	1.06	Lindon	3.33	1.19
H26	V2	8/28/2023	7.65	6.16	1.24	Lindon	6.08	1.01
H32	V1	8/28/2023	6.76	7.74	0.87	Lindon	6.13	1.26
H19	V3	8/31/2023	1.39	5.01	0.28	Spanish Fork	7.13	0.70

Figure S8 shows the I/O ratios organized by house number and visit for the final dataset.

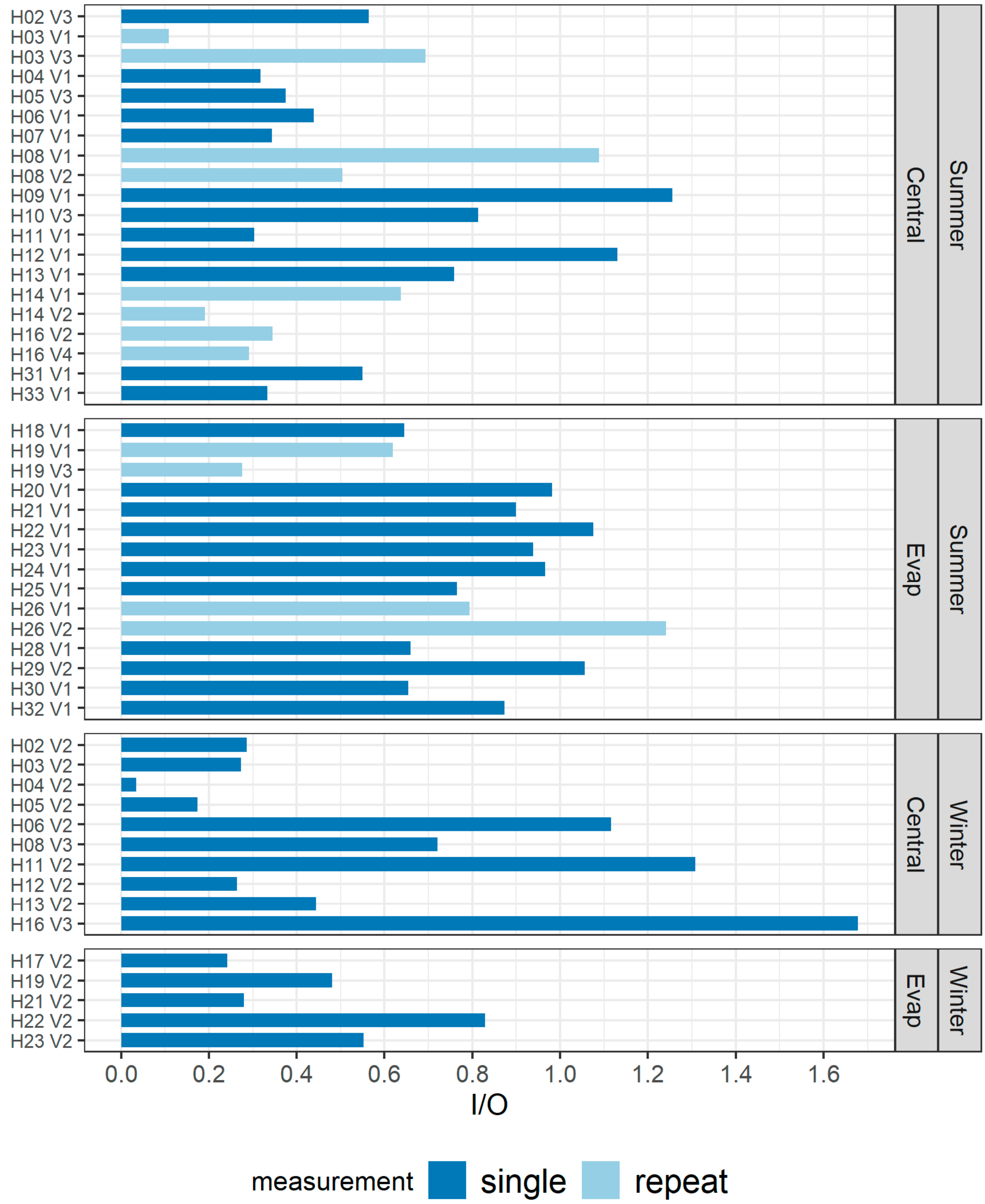

Figure S8. I/O ratio for each visit. Repeated measurements from the same house during the same season are colored in light-blue.

Figure S9 displays the box plots of the concentration data and I/O ratios for the summer visits when the wildfire event visits were removed.

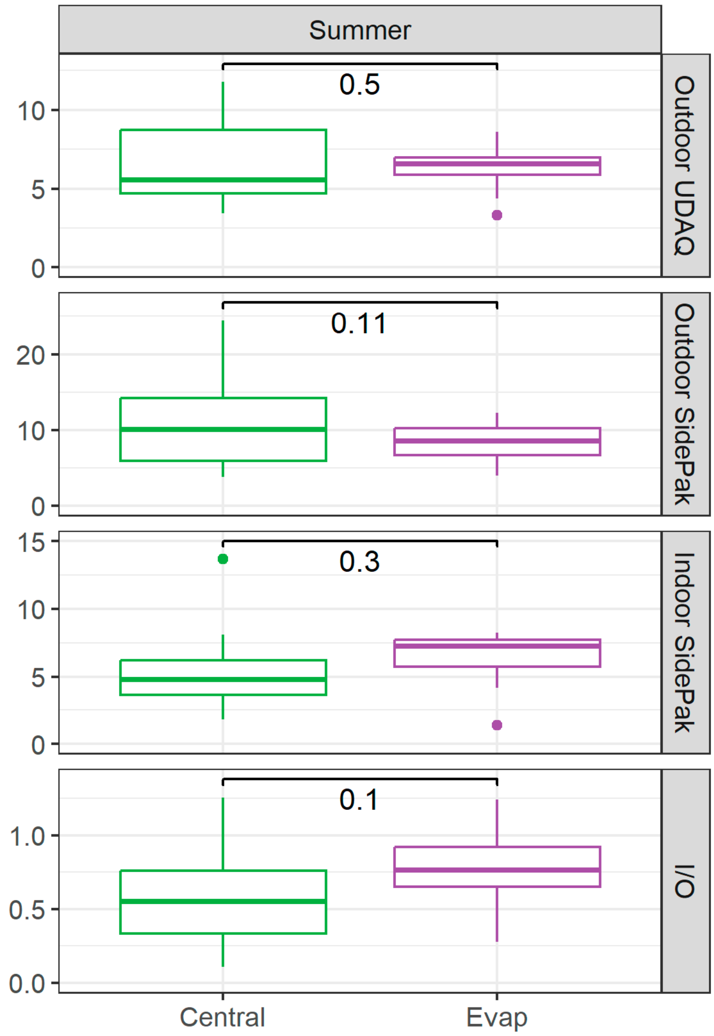

Figure S9. Box plots of average concentration statistics from the summer house visits organized by air conditioner type. The seven house visits that occurred during the September 8-12, 2022 wildfire smoke event were removed. The horizon lines and numbers are the p-values comparing the averages from a two-sample t-test.

S.6 Temperature and relative humidity data

Table S5. Summary statistics of the average indoor temperature, °C, from each home visit by air conditioning type and season in Utah County.

	N	Temperature (Indoor)				Temperature (Outdoor)			
		Mean	s.d.	Min	Max	Mean	s.d.	Min	Max
Summer	33								
Central	19	22.6	1.6	16.6	24.1	26.1	3.2	20.4	31.8
Evaporative	14	22.2	1.7	19.7	25.8	25.8	3.0	21.3	31.9
Winter	12								
Central	7	19.3	0.7	18.2	20.1	1.1	2.7	-1.8	5.5
Evaporative	5	20.3	0.9	18.9	21.5	3.9	4.2	0.2	11.0

Table S6. Summary statistics of the average relative humidity from each home visit by air conditioning type and season in Utah County

	N	RH (Indoor)				RH (Outdoor)			
		Mean	s.d.	Min	Max	Mean	s.d.	Min	Max
Summer	33								
Central	19	44.6	6.4	34.7	58.1	44.3	15.1	24.6	73.3
Evaporative	14	52.5	11.9	31.2	76.2	37.2	12.6	17.6	63.3
Winter	12								
Central	7	33.0	5.5	27.4	42.1	60.6	10.8	43.4	74.1
Evaporative	5	24.0	4.8	19.6	31.4	50.5	21.0	25.4	72.6

Table S7. Summary statistics of the maximum outdoor temperature °C from each summer home visit by air conditioning type in Utah County.

	N	Temperature(max)			
		Mean	s.d.	Min	Max
Summer	29				
Central	16	45.1	10.5	22.1	59.4
Evaporative	13	42.7	11.7	24.4	62.2

Table S8. Summary statistics of the minimum outdoor temperature °C from each winter home visit by air conditioning type in Utah County.

	N	Temperature (min)			
		Mean	**s.d.**	**Min**	**Max**
Winter	15				
Central	10	-6.4	2.7	-9.4	-0.3
Evaporative	5	-1.6	2.3	-4.1	0.7

S.7 Infiltration Factor Estimates using Method 1

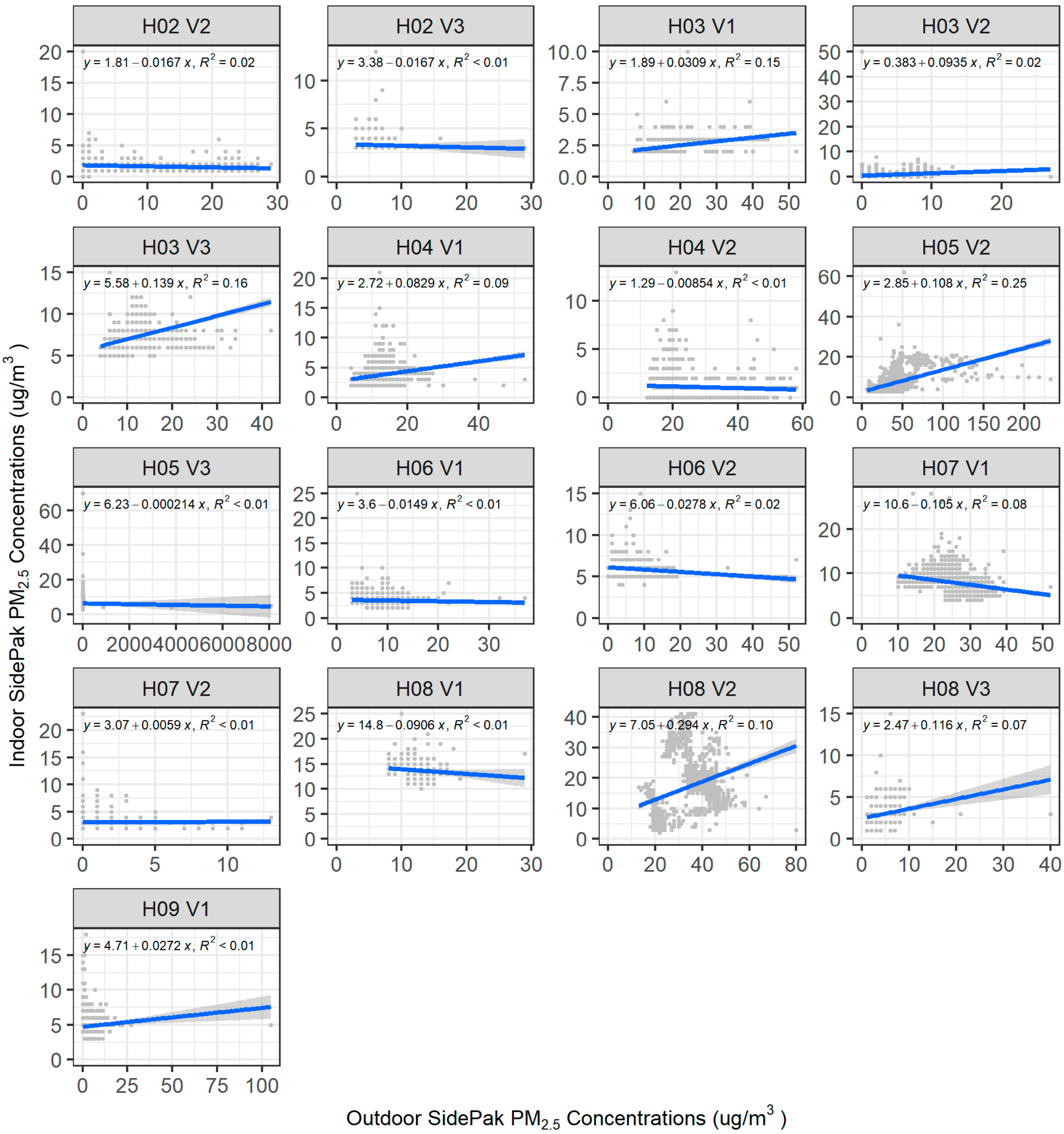

Figure S10. Correlation of indoor and outdoor SidePak $PM_{2.5}$ concentrations for visits at houses H02 through H09.

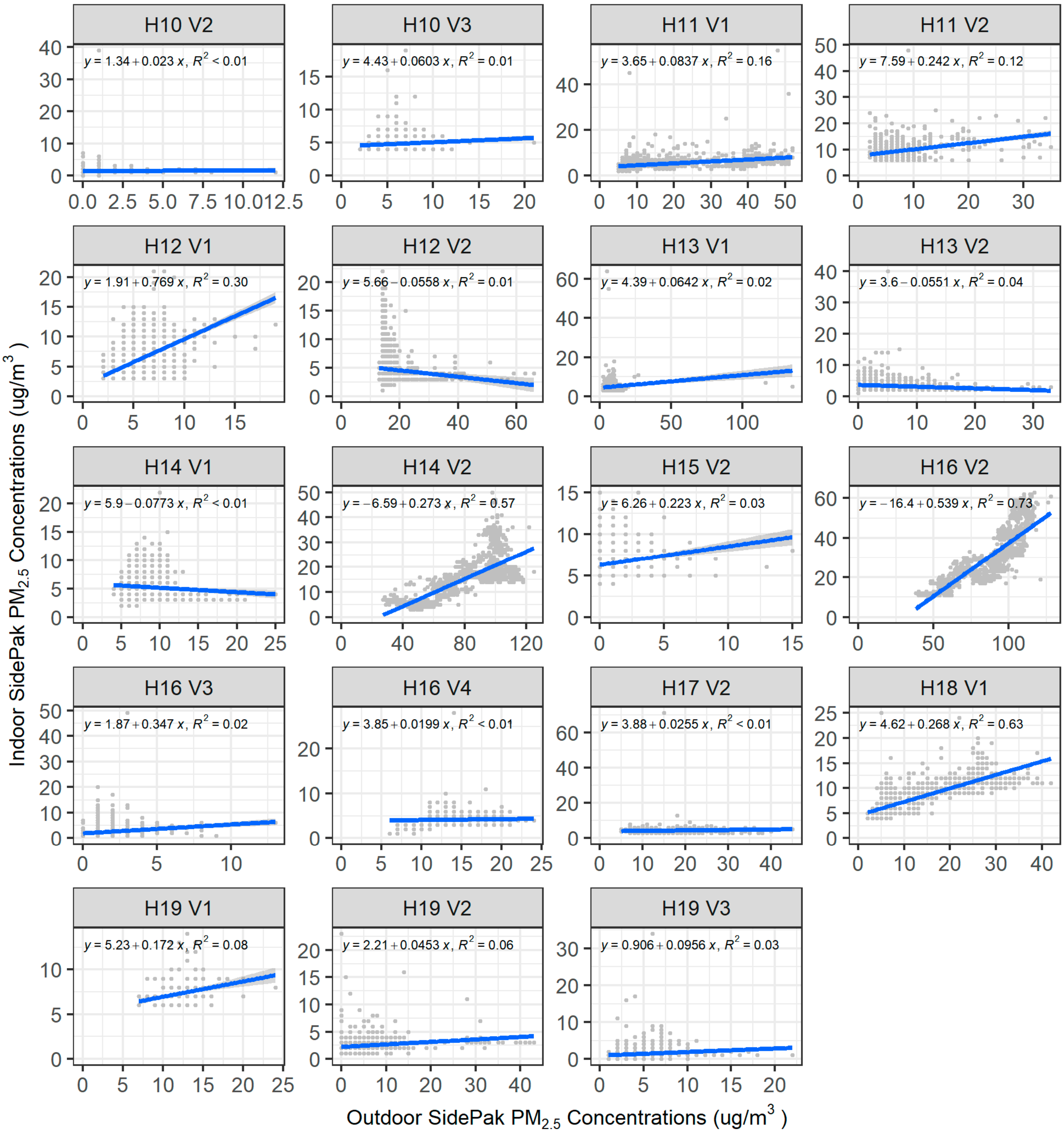

Figure S11. Correlation of indoor and outdoor SidePak $PM_{2.5}$ concentrations for visits at houses H10 through H19.

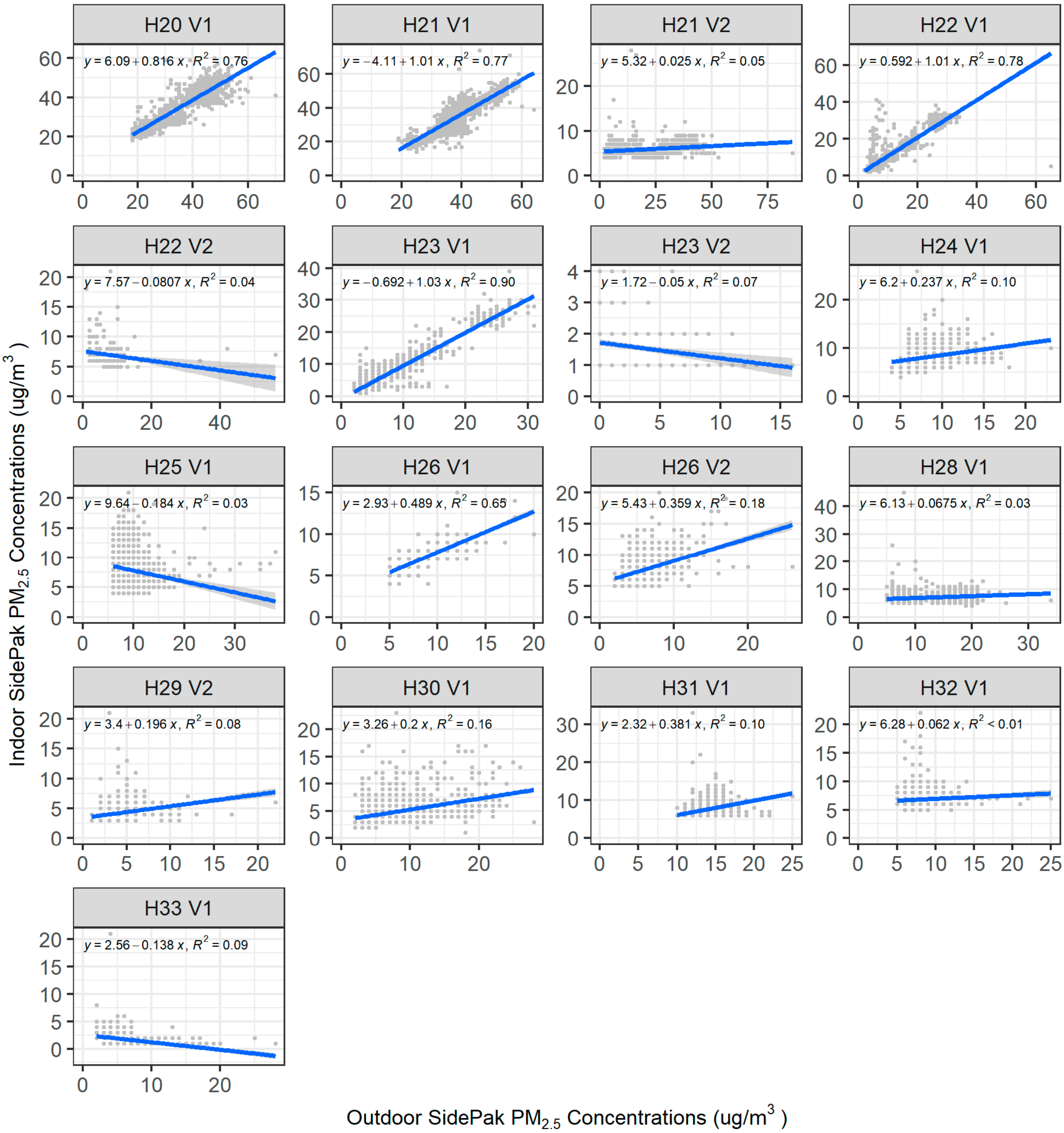

Figure S12. Correlation of indoor and outdoor SidePak $PM_{2.5}$ concentrations for visits at houses H20 through H33.

Table S9. Estimated Indoor Contribution (C_s) and Infiltration Factor (F_{in})and goodness of fit (R^2) and significance (p-value) from fitting Equation (1) to each AC visit. The lower (2.5%) and upper (97.5%) bounds on the 95% confidence intervals are estimated for C_s and F_{in}.

House Number	Visit	Date	C_s	C_s (2.5%)	C_s (97.5%)	F_{in}	F_{in} (2.5%)	F_{in} (97.5%)	R^2
H03	V1	7/27/2022	1.89	1.72	2.07	0.03	0.02	0.04	0.15
H04	V1	7/28/2022	2.72	2.54	2.89	0.08	0.07	0.10	0.09
H06	V1	8/1/2022	3.60	3.45	3.75	-0.01	-0.03	0.00	0.00
H07	V1	8/3/2022	10.56	10.09	11.03	-0.11	-0.12	-0.09	0.08
H08	V1	8/9/2022	14.80	13.40	16.20	-0.09	-0.20	0.02	0.01
H09	V1	8/9/2022	4.71	4.61	4.80	0.03	0.01	0.04	0.01
H13	V1	8/10/2022	4.39	4.19	4.60	0.06	0.04	0.09	0.02
H12	V1	8/11/2022	1.91	1.52	2.29	0.77	0.70	0.84	0.30
H14	V1	8/15/2022	5.90	5.52	6.29	-0.08	-0.12	-0.03	0.01
H11	V1	8/16/2022	3.65	3.44	3.87	0.08	0.07	0.09	0.16
H08	V2	9/8/2022	7.05	5.32	8.77	0.29	0.24	0.34	0.10
H14	V2	9/9/2022	-6.59	-7.61	-5.57	0.27	0.26	0.29	0.57
H16	V2	9/9/2022	-16.41	-17.91	-14.91	0.54	0.52	0.56	0.73
H11	V2	11/16/2022	7.59	7.20	7.97	0.24	0.20	0.29	0.12
H06	V2	11/17/2022	6.06	6.00	6.13	-0.03	-0.04	-0.02	0.02
H02	V2	11/21/2022	1.81	1.75	1.87	-0.02	-0.02	-0.01	0.02
H03	V2	12/8/2022	0.38	0.25	0.51	0.09	0.05	0.13	0.02
H04	V2	1/25/2023	1.29	1.14	1.44	-0.01	-0.01	0.00	0.01
H05	V2	2/2/2023	2.85	2.37	3.33	0.11	0.10	0.12	0.25
H12	V2	3/27/2023	5.66	5.19	6.13	-0.06	-0.08	-0.03	0.01
H16	V3	3/30/2023	1.87	1.67	2.07	0.35	0.23	0.46	0.02
H13	V2	4/4/2023	3.60	3.46	3.73	-0.06	-0.07	-0.04	0.04
H08	V3	4/13/2023	2.47	2.19	2.75	0.12	0.07	0.16	0.07
H03	V3	8/3/2023	5.58	5.39	5.76	0.14	0.12	0.16	0.16
H10	V3	8/3/2023	4.43	4.26	4.61	0.06	0.03	0.09	0.01
H16	V4	8/14/2023	3.85	3.56	4.14	0.02	0.00	0.04	0.00
H02	V3	8/15/2023	3.38	3.11	3.64	-0.02	-0.06	0.03	0.00
H05	V3	8/21/2023	6.23	6.00	6.45	0.00	0.00	0.00	0.00
H31	V1	8/24/2023	2.32	1.52	3.12	0.38	0.32	0.44	0.10
H33	V1	8/31/2023	2.56	2.42	2.71	-0.14	-0.16	-0.11	0.09

Table S10. Estimated Indoor Contribution (C_s) and Infiltration Factor (F_{in}) and goodness of fit (R^2) and significance (p-value) from fitting Equation (1) to each EC visit. The lower (2.5%) and upper (97.5%) bounds on the 95% confidence intervals are estimated for C_s and F_{in}.

House Number	Visit	Date	C_s	C_s (2.5%)	C_s (97.5%)	F_{in}	F_{in} (2.5%)	F_{in} (97.5%)	R^2
H18	V1	9/1/2022	4.62	4.45	4.78	0.27	0.26	0.28	0.63
H19	V1	9/2/2022	5.23	4.41	6.05	0.17	0.10	0.24	0.08
H20	V1	9/8/2022	6.09	5.16	7.01	0.82	0.79	0.84	0.76
H21	V1	9/8/2022	-4.11	-5.21	-3.01	1.01	0.98	1.04	0.77
H22	V1	9/12/2022	0.59	0.26	0.93	1.01	0.98	1.04	0.78
H23	V1	9/12/2022	-0.69	-0.86	-0.52	1.03	1.01	1.05	0.90
H21	V2	12/8/2022	5.32	5.18	5.47	0.02	0.02	0.03	0.05
H17	V2	1/27/2023	3.88	3.35	4.41	0.03	0.00	0.05	0.00
H19	V2	2/10/2023	2.21	2.13	2.29	0.05	0.04	0.05	0.06
H22	V2	3/3/2023	7.57	7.12	8.01	-0.08	-0.13	-0.03	0.04
H23	V2	4/6/2023	1.72	1.60	1.83	-0.05	-0.07	-0.03	0.07
H24	V1	7/13/2023	6.20	5.87	6.53	0.24	0.20	0.27	0.10
H25	V1	7/13/2023	9.64	9.10	10.18	-0.18	-0.23	-0.13	0.03
H26	V1	7/20/2023	2.93	2.55	3.31	0.49	0.45	0.53	0.65
H28	V1	7/27/2023	6.13	5.89	6.37	0.07	0.05	0.09	0.03
H30	V1	8/10/2023	3.26	3.06	3.47	0.20	0.18	0.22	0.16
H29	V2	8/21/2023	3.40	3.23	3.57	0.20	0.16	0.24	0.08
H26	V2	8/28/2023	5.43	5.17	5.70	0.36	0.32	0.40	0.18
H32	V1	8/28/2023	6.28	5.97	6.59	0.06	0.02	0.10	0.01
H19	V3	8/31/2023	0.91	0.73	1.08	0.10	0.06	0.13	0.03

S.8 Summary Statistics from Method 1

Equations for Calculating the Averages C_s, F_{in}, and R_2

$$\overline{C_s} = \frac{\sum_{i=1}^{n} C_{s,i}}{n} \tag{S1}$$

Where:
$C_{s,i}$= Intercept, $PM_{2.5}$ contribution (μg/m^3) from indoor sources for visit i
n = Number of visits grouped by air conditioner type (AC or EC) and season (Winter and Summer)
$\overline{C_s}$= Average indoor contribution by group (air conditioner type and season).

$$\overline{F_{in}} = \frac{\sum_{i=1}^{n} F_{in,i}}{n} \tag{S2}$$

Where:
$F_{in,i}$= Infiltration factor for visit i
n = Number of visits grouped by air conditioner type (AC or EC) and season (Winter and Summer)
$\overline{F_{in}}$= Average infiltration factor by group (air conditioner type and season).

$$\overline{R_2} = \frac{\sum_{i=1}^{n} R_{2,i}}{n} \tag{S3}$$

Where:
$R_{2,i}$= R_2 goodness of fit for visit i
n = Number of visits grouped by air conditioner type (AC or EC) and season (Winter and Summer)
$\overline{R_2}$= Average R_2 by group (air conditioner type and season).

Table S11. Summary statistics from concentrations, I/O, and output from Method 1 calculations.

		Central Air Conditioning			Evaporative Cooler			
statistic	season	Mean	SD	n	Mean	SD	n	p-value
Outdoor UDAQ	Summer	9.51	7.64	20	7.93	3.89	15	0.43
Outdoor UDAQ	Winter	8.90	7.21	10	5.96	2.81	5	0.28
Outdoor SidePak	Summer	19.51	22.82	20	12.17	10.13	15	0.21
Outdoor SidePak	Winter	12.41	13.87	10	11.02	7.99	5	0.81
Indoor SidePak	Summer	7.68	6.53	20	10.41	9.94	15	0.37
Indoor SidePak	Winter	3.93	2.89	10	4.22	2.23	5	0.83
I/O	Summer	0.55	0.32	20	0.83	0.24	15	0.01
I/O	Winter	0.63	0.56	10	0.48	0.24	5	0.47
Cs	Summer	3.33	6.14	20	3.73	3.43	15	0.81
Cs	Winter	3.36	2.34	10	4.14	2.39	5	0.56
Fin	Summer	0.12	0.23	20	0.39	0.39	15	0.03
Fin	Winter	0.07	0.14	10	-0.01	0.05	5	0.12
R^2	Summer	0.13	0.20	20	0.34	0.35	15	0.04
R^2	Winter	0.06	0.07	10	0.04	0.03	5	0.58

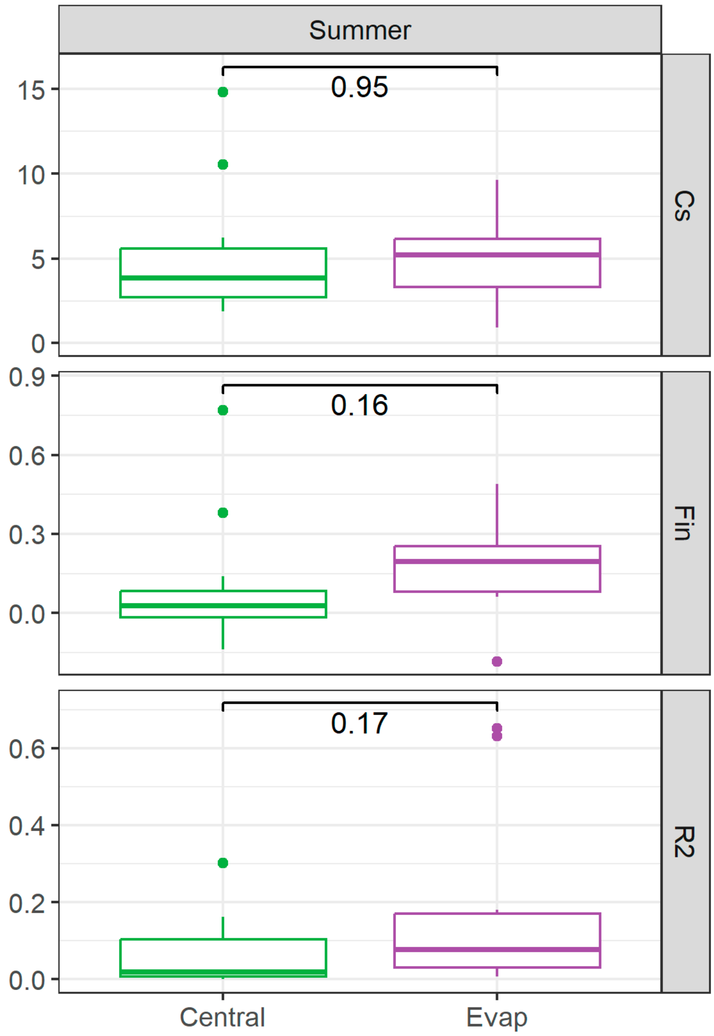

Figure S13. Box plots of the C_s, F_{in}, and R^2 estimated for each house visit organized by air conditioner type for summer visits with the wildfire visits removed. The horizontal black lines and numbers are the p-values comparing the averages from two-sample t-tests.

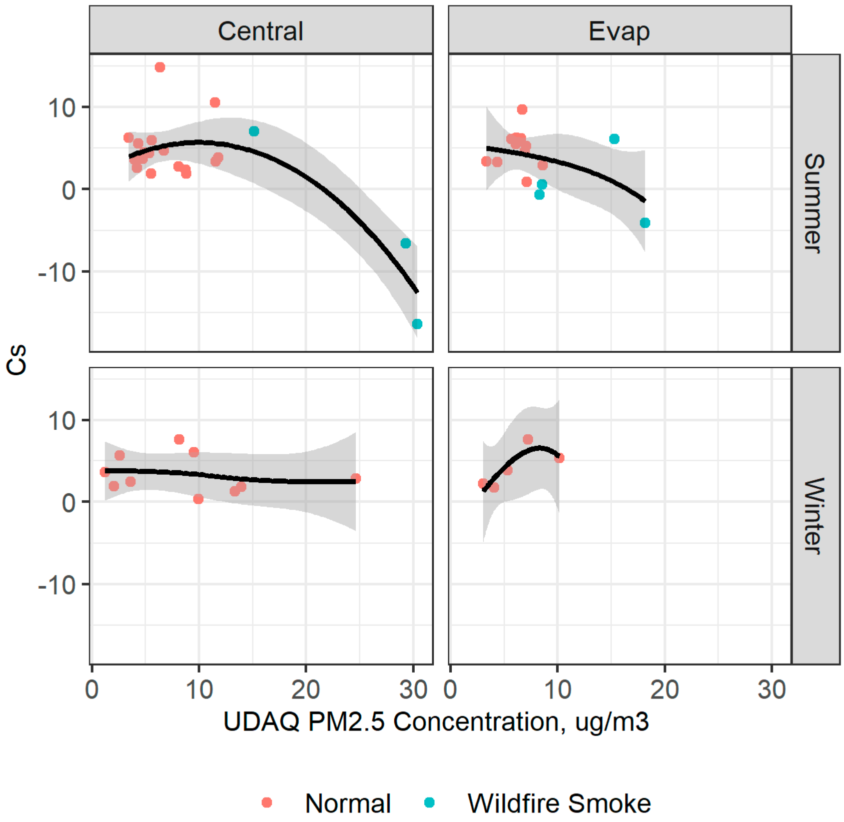

Figure S14. Correlation of C_s (Contribution of Indoor Sources) with outdoor $PM_{2.5}$ concentrations measured from the nearest Utah Division of Air Quality (UDAQ) monitor to the house. The black line is a Loess smoothing function, and the grey shadow shows the observations that are within the standard error of the model predictions [42].

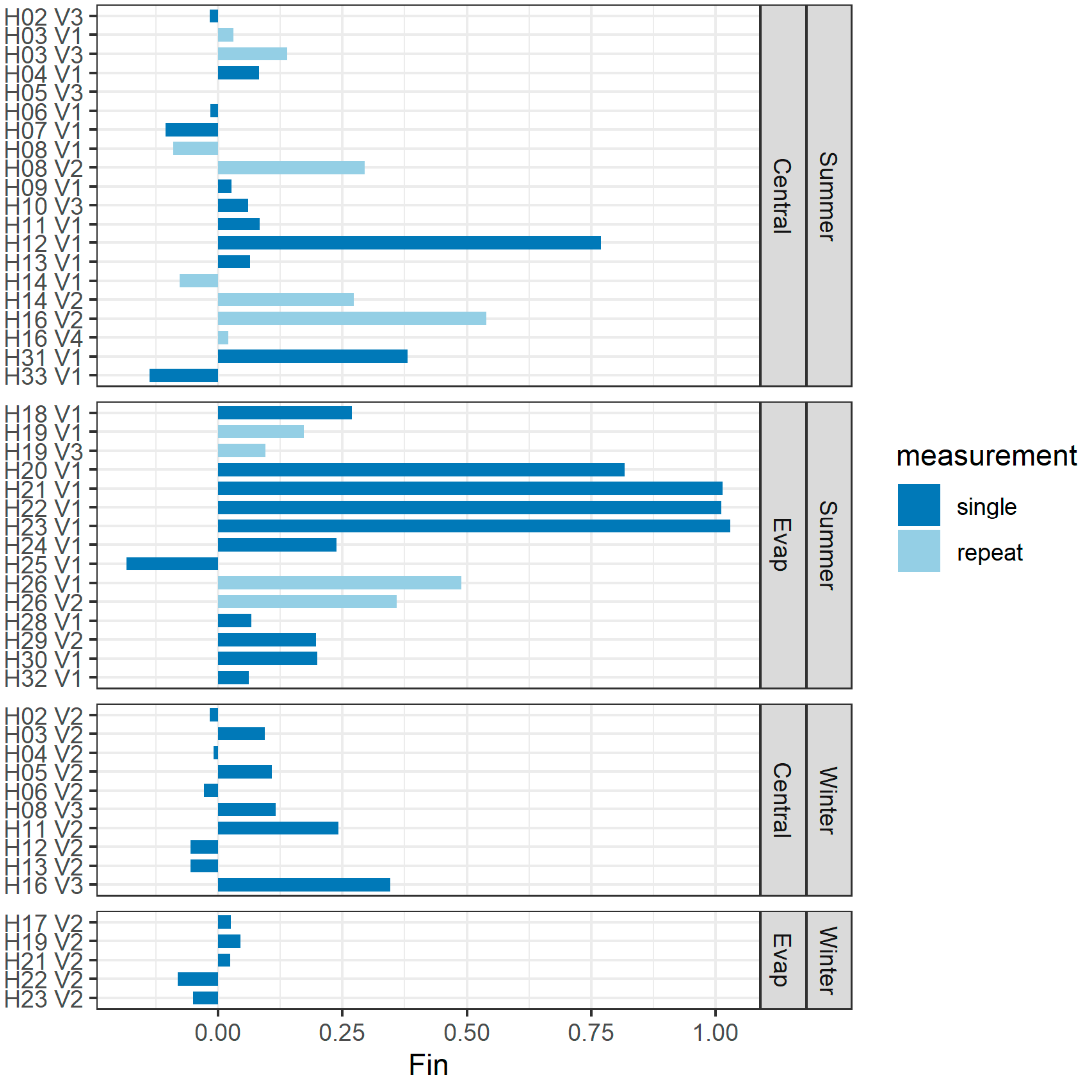

Figure S15. Infiltration Factor (Fs) estimated for each house visit. The repeated measurements from the same house during the same season are indicated in light-blue.

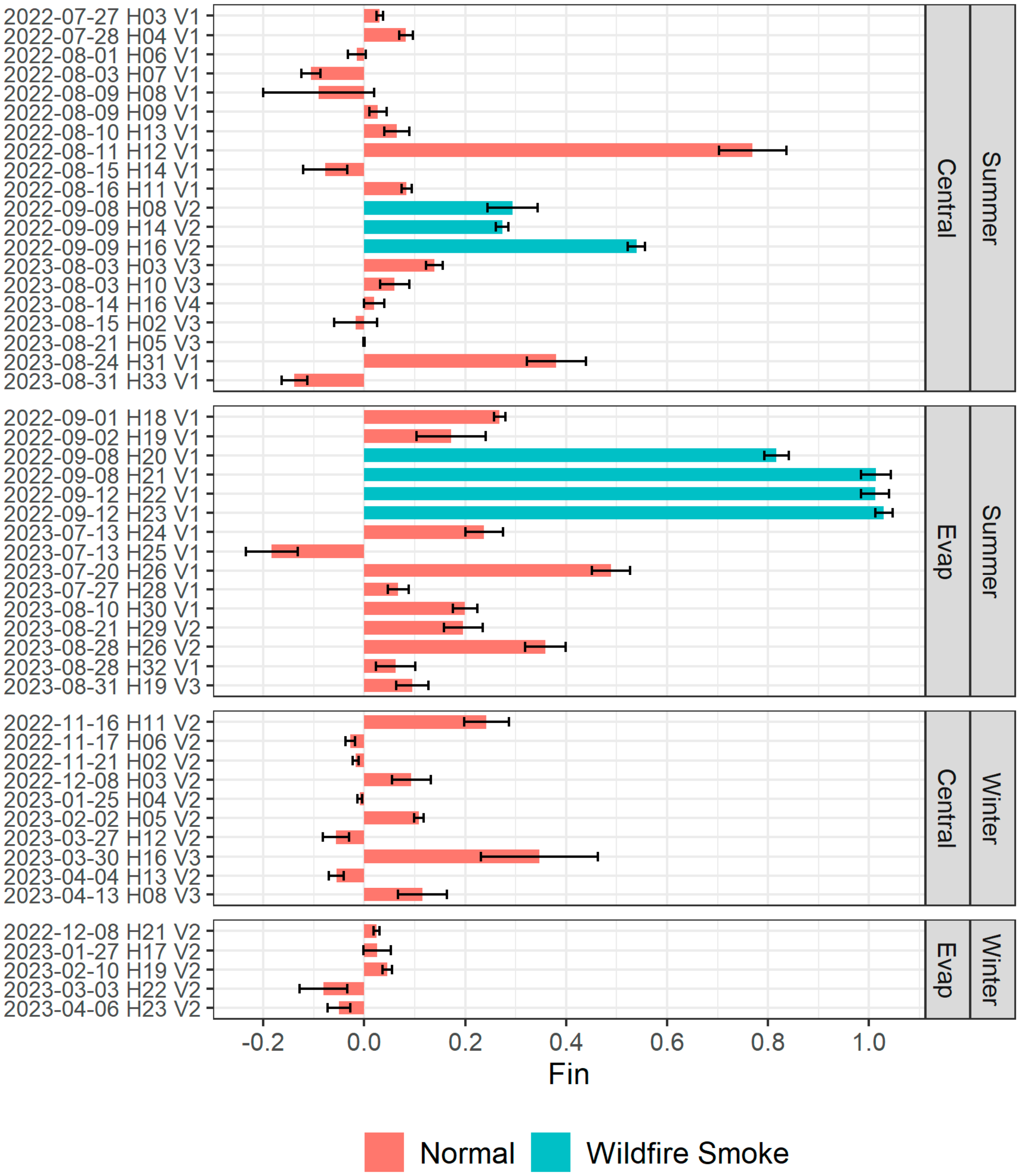

Figure S16. Infiltration Factor (F_{in}) estimated for each house visit organized by season, air conditioning type and date. Error bars are the 95% confidence intervals of the F_{in} estimate.

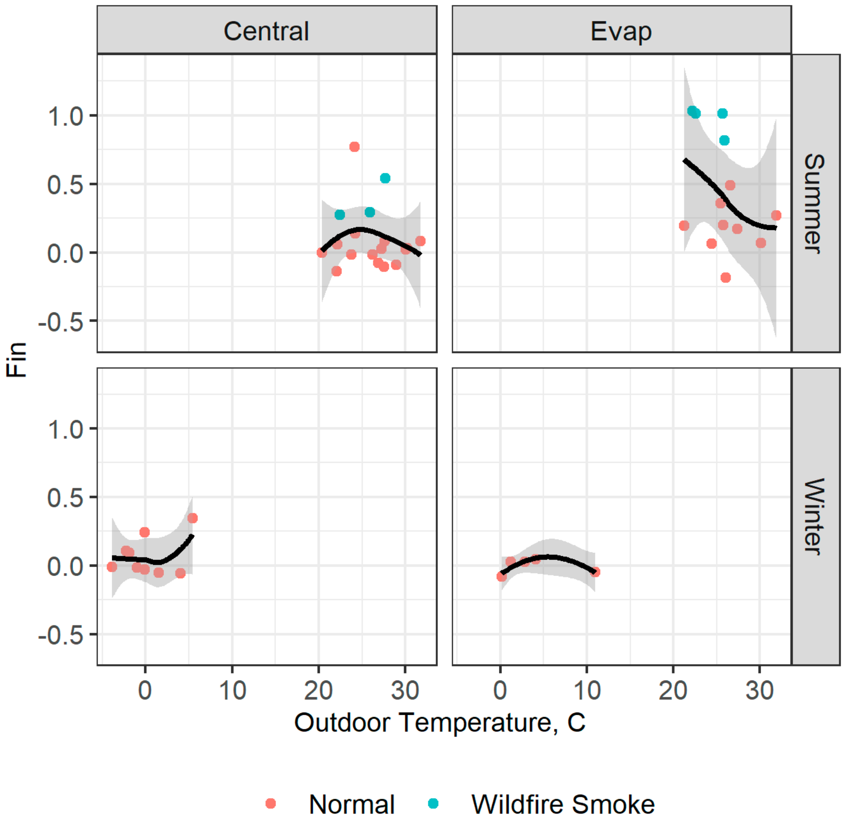

Figure S17. Correlation of Infiltration Factors (F_{in}) with outdoor average temperature

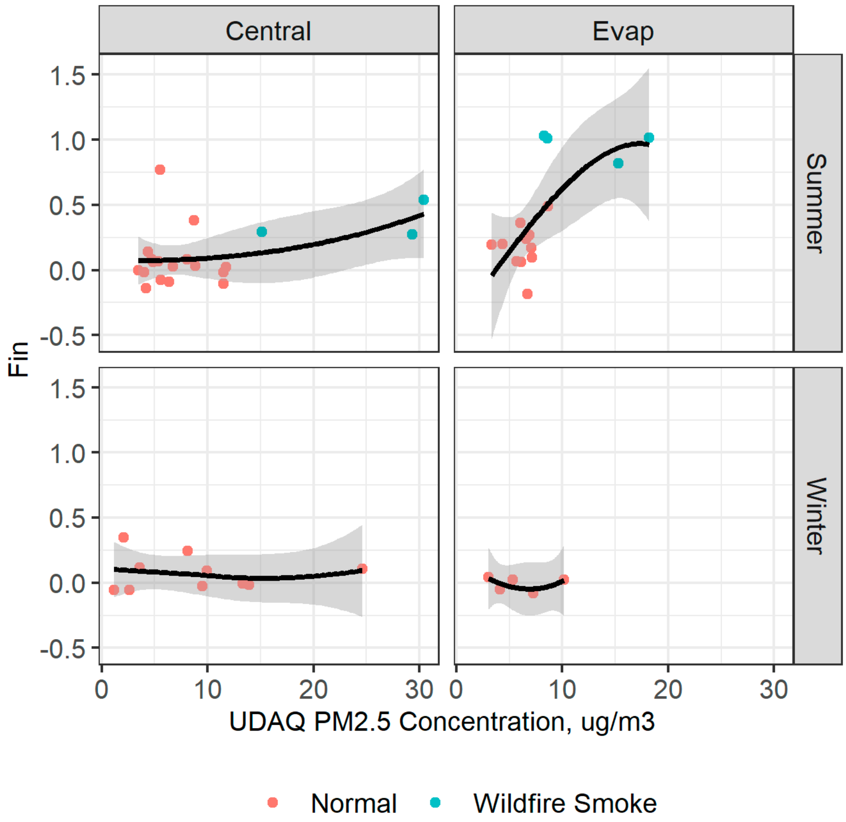

Figure S18. Correlation of Infiltration Factors (F_{in}) with outdoor $PM_{2.5}$ concentrations measured from the nearest Utah Division of Air Quality (UDAQ) monitor to the house.

S.9 Infiltration Factor Estimates using Method 2

Table S12. Model coefficients for C_{in} and F_{in} by air conditioner type and season estimated using Equation (1)

Group	Observations	Coefficient	Estimate	Std Error	t-value	2.5th percentile	97.5th percentile	p-value
AC + Summer	20	C_{in}	3.02	1.10	2.75	0.72	5.32	0.01
		F_{in}	0.24	0.04	6.43	0.16	0.32	4.7E-06
EC + Summer	15	C_{in}	-1.32	0.80	-1.64	-3.04	0.40	0.12
		F_{in}	0.96	0.05	18.73	0.85	1.07	8.7E-11
AC + Winter	10	C_{in}	3.21	1.28	2.51	0.32	6.10	0.04
		F_{in}	0.06	0.07	0.81	-0.10	0.22	0.44
EC + Winter	5	C_{in}	2.41	1.72	1.40	-2.36	7.19	0.26
		F_{in}	0.16	0.13	1.25	-0.20	0.53	0.30
AC + Summer + No Wildfire	17	C_{in}	4.43	1.41	3.15	1.45	7.41	6.6E-03
		F_{in}	0.09	0.11	0.80	-0.14	0.32	0.43
EC + Summer + No Wildfire	11	C_{in}	1.80	1.66	1.09	-1.89	5.49	0.31
		F_{in}	0.54	0.19	2.90	0.13	0.96	0.02

Statistical Comparison of Method 2 F_{in} by air conditioner type

To determine if the infiltration factor (F_{in}) estimated using method 2 was significantly different between the house visits with central air conditioners and evaporative coolers, we pooled the average SidePak $PM_{2.5}$ concentrations data from each house visits within each season and fit the linear model shown in equation (S4).

$$C_{in\,i} = C_s + EVAP + F_s\, C_{out\,i} + (F_s \times EVAP)\, C_{out\,i} + e_i, \quad \text{(S4)}$$

Where:

$C_{in\,i}$ = Average Indoor SidePak $PM_{2.5}$ concentration (ug/m3) for visit, i

C_s= Intercept, Average $PM_{2.5}$ contribution (ug/m3) from indoor sources

EVAP = effect of evaporative cooler on C_s (ug/m3

$C_{out\,i}$= Average Outdoor SidePak $PM_{2.5}$ concentration (ug/m3) for visit, i

F_{in}= Slope (Average Infiltration factor)

$F_s \times EVAP$ = interaction effect of evaporative cooler on F_{in}

E_{in} = Error in the linear model fit for visit, i

The results of the model fit are displayed in Table S13 for the summer visits and in Table S14 for the winter observations. For the summer visits, the infiltration factor (F_{in}) is larger for visits with evaporative coolers than homes with central air conditioners with a high degree of significance. For the winter visits, the infiltration factor is larger for homes with evaporative coolers, but the difference is not statistically significant.

Table S13. Model coefficients for the summer observations (n=35)

	Estimate	Std Error	t-value	$p > \|t\|$
C_{in}	0.85	0.78	1.08	0.19
EVAP	-3.07	1.11	-2.77	0.01
F_s	0.60	0.04	13.81	4.5E-14
F_s × EVAP	0.51	0.06	8.32	5.0E-09

Table S14. Model coefficients for the winter observations (n=15)

	Estimate	Std Error	t-value	$p > \|t\|$
C_{in}	2.81	1.27	2.21	0.05
EVAP	-0.57	1.80	-0.31	0.76
F_s	0.11	0.09	1.21	0.25
F_s × EVAP	0.08	0.13	0.58	0.57

We also fit the linear regression model in Equation S4 to the summer observations, with the seven days with wildfire smoke removed. F_{in} is still much larger for the visits with evaporative coolers, but the effect is no longer significant (p-value = 0.14. Table S15).

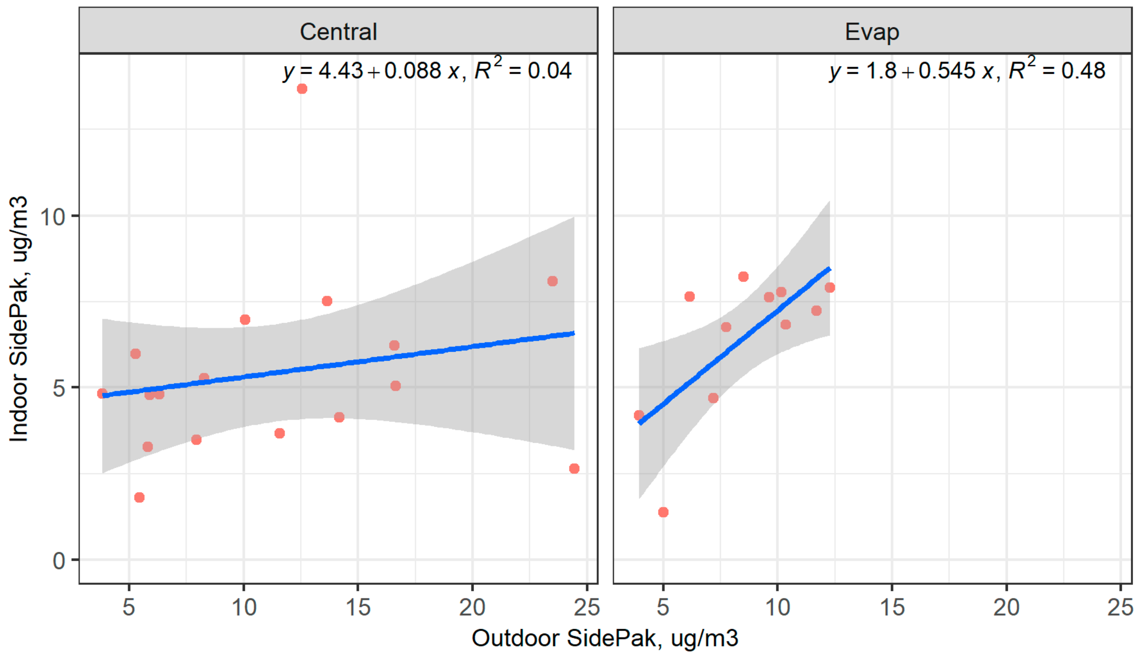

Figure S19. Average indoor and outdoor SidePak $PM_{2.5}$ concentrations for the summer home visits by air conditioner type, with the five visits that occurred on wildfire smoke days removed (Reference outdoor $PM_{2.5} > 15$ μg/m³)

Table S15. Model coefficients for the summer observations without the days with wildfire smoke (n=28)

	Estimate	Std Error	t-value	$p > \|t\|$
C_{in}	4.43	1.22	3.63	0.00
EVAP	-2.63	2.75	-0.96	0.35
F_s	0.09	0.10	0.92	0.36
F_s × EVAP	0.46	0.30	1.55	0.14

S.10. Comparison of Infiltration Factor Estimates using Method 1 and Method 2

Table S16. Comparison of Infiltration Factor Estimates using Method 1 and Method 2

		Central Air (AC)			Evaporative (EC)		
Season		Estimate	Lower 95%	Upper 95%	Estimate	Lower 95%	Upper 95%
Summer	Mean F_{in} from Method 1	0.12	0.01	0.22	0.39	0.17	0.61
	F_{in} from Method 2	0.23	0.15	0.32	0.96	0.85	1.07
Winter	Mean F_{in} from Method 1	0.07	-0.02	0.17	-0.01	-0.08	0.06
	F_{in} from Method 2	0.06	-0.10	0.22	0.16	-0.20	0.53

S.11 References

55. US EPA. Outdoor Air Quality Data. 2023. https://www.epa.gov/outdoor-air-quality-data/download-daily-data (accessed 2023 November 13, 2023).

56. US EPA. AirNow API. 2023. https://docs.airnowapi.org/ (accessed 2023 November 14, 2023).

57. UDAQ. Annual Monitoring Network Plan 2022. Utah Department of Environmental Quality, 2023. https://documents.deq.utah.gov/air-quality/planning/air-monitoring/DAQ-2022-007189.pdf (accessed 2023 July 19, 2022).

58. National Weather Service. NOWData - NOAA Online Weather Data. 2023. https://www.weather.gov/wrh/Climate?wfo=slc (ac-cessed 2023 11/10/2023).