Supplementary Materials:

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Development of a dilution model

A simple *mechanistically-based* model was used to show the effect of meteorological conditions, including boundary layer height, wind speed and barometric pressure, on monitoring results measured by MPAL around the landfill. The model follows from a simplified line source model in which the landfill is considered as the only local CH_4 s source, which is assumed to extend perpendicular to the wind direction for a sufficient distance such that a 1-D model can be used to represent downwind concentrations. Assuming a constant baseline (or background) concentration $C_{baseline}$, and dilution of emissions into a fully mixed layer extending between the ground level and the boundary layer height H (m), the model can be represented as:

$$Q = H\,u\,(C - C_{baseline}) \quad \text{(S1)}$$

where Q is the CH_4 emission rate of the line source in mg/hr-m, H is the hourly average boundary layer height (m), u is the hourly average wind speed (m/s), C is the maximum CH_4 measurements (mg/m^3), and $C_{baseline}$ is the CH_4 baseline concentration (mg/m^3) From Eq. 1, it can be derived that:

$$C \propto Q\,(H\,u)^{-1} \quad \text{(S2)}$$

To eq. S2, we added terms to describe the influence of several factors on the average emission rate Q. Czepiel et al. [1] reported a significant inverse linear relationship between landfill CH_4 emissions and atmospheric pressure. Additionally, landfill temperature affects the rate of microbial methanogenesis and CH_4 emissions [2] such that:

$$C \propto P\,T_{soil}\,(H\,u)^{-1} \quad \text{(S3)}$$

where P is the barometric pressure and T_{soil} is the estimated soil temperature. In this study, we examined use of both the hourly average barometric pressure (P) and the 6-hour barometric pressure change (ΔP_{6h}). The final model, Eq. 2 and Model 6 in Table 3 in the main text, were based on Eq. S3.

Table S1. Visit date, time, number of observations and average, standard deviation (SD) and top CH4 concentration percentiles (in ppm) at Landfill C.

Date	Start Time	End Time	NOBs	Average	SD	95%	98%	99%	99.90%	Max
5/19/2021	15:31:27	15:46:11	885	2.79	1.84	7.12	8.70	10.64	12.26	12.26
5/27/2021	16:10:56	16:26:05	909	2.04	0.20	2.31	2.86	3.24	3.33	3.33
6/2/2021	12:14:18	12:30:26	965	2.67	1.13	4.71	7.09	8.30	10.35	10.35
6/5/2021	7:10:50	10:38:33	1102	3.29	1.74	6.89	7.38	8.86	11.67	11.67
6/7/2021	15:47:12	16:05:43	1112	2.60	0.97	4.21	5.24	6.51	7.03	7.04
6/8/2021	9:44:00	10:01:07	1028	2.39	0.69	3.61	4.32	4.64	5.32	5.33
6/9/2021	12:47:44	12:59:55	732	2.33	0.93	3.25	6.08	8.14	9.77	9.77
6/16/2021	10:40:54	10:56:09	913	2.04	0.03	2.09	2.12	2.18	2.25	2.25
6/23/2021	9:02:04	9:19:02	1018	3.80	1.93	7.23	7.85	8.11	8.90	8.90
7/1/2021	13:30:47	13:52:34	1297	2.11	0.18	2.56	2.66	2.71	2.95	2.95
7/19/2021	17:29:00	20:14:00	9881	3.15	1.57	6.61	8.52	9.75	12.55	13.34
7/20/2021	6:08:41	8:59:04	10203	5.66	2.78	10.60	12.33	13.68	16.29	20.70
8/3/2021	6:23:43	8:59:34	9295	7.24	5.92	19.03	22.83	24.69	30.93	36.38
9/20/2021	7:10:26	10:26:00	8273	6.80	5.73	19.43	21.92	23.11	25.12	26.42
9/29/2021	8:03:57	10:30:23	6256	3.55	1.50	6.65	7.82	8.27	8.80	8.81

Table S2. Maximum CH4 concentrations (in ppm) measured at each landfill at different averaging times.

Landfill	1s	5s	10s	20s	60s
Phase 1: 05/19 --07/01					
A	5.71	5.70	5.64	5.61	5.10
B	10.57	10.34	9.89	8.37	7.15
C	12.26	11.54	10.37	9.16	7.27
D	7.45	6.77	5.69	5.47	4.15
E	3.97	3.90	3.57	3.53	3.06
F	4.49	4.42	4.27	4.23	3.33
G	4.69	4.63	4.56	4.36	3.51
H	4.61	4.49	4.19	3.90	2.85
Phase 2: 07/19 --09/29					
A	16.02	15.32	14.94	14.03	11.18
B	37.58	37.22	33.76	28.67	19.32
C	36.38	33.96	28.06	26.10	24.21
D	29.69	28.44	27.45	26.62	26.41

Table S3. Results for the multivariate models. Parameters estimated using bootstrapping.

Equation	Conc.	R^2	k_1	k_2	k_3	k_4	k_5	k_6	k_7
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}$	Ave	0.564	2.52	-2.74	2.81	-2.99	-	-	-
	98%	0.618	4.94	-10.13	10.34	-13.49	-	-	-
	99%	0.626	5.83	-11.21	10.82	-15.06	-	-	-
	Max	0.734	5.88	-14.34	17.24	-21.92	-	-	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$	Ave	0.705	0.64	-1.79	1.86	-1.92	0.14	-	-
	98%	0.685	0.20	-7.73	7.94	-10.78	0.35	-	-
	99%	0.667	1.92	-9.23	8.85	-12.83	0.28	-	-
	Max	0.755	1.90	-12.32	15.23	-19.64	0.29	-	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ + $k_6/(H\ u)$	Ave	0.711	0.37	12.25	2.44	-1.79	0.14	-40.51	-
	98%	0.710	-1.88	100.89	12.47	-9.76	0.37	-313.60	-
	99%	0.705	-0.78	131.56	14.71	-11.51	0.32	-406.47	-
	Max	0.774	-0.79	127.96	21.07	-18.32	0.32	-405.01	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ +$k_6\ P_{g,6h}/H$	Ave	0.722	0.06	7.55	1.71	-1.29	0.17	-58.36	-
	98%	0.732	-3.29	48.57	7.06	-6.99	0.52	-351.76	-
	99%	0.725	-2.21	57.32	7.81	-8.36	0.49	-415.78	-
	Max	0.780	-1.94	49.46	14.26	-15.49	0.48	-385.99	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ +$k_6\ T_{soil,30}/H$	Ave	0.705	0.79	-8.80	1.85	-1.99	0.13	0.50	-
	98%	0.687	-0.99	49.00	8.05	-10.25	0.41	-4.06	-
	99%	0.672	-0.05	84.33	9.02	-11.96	0.39	-6.70	-
	Max	0.755	1.23	19.58	15.29	-19.34	0.33	-2.28	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ +$k_6\ P_{g,6h}/u$	Ave	0.786	0.16	-1.13	1.20	5.50	0.18	-22.86	-
	98%	0.748	-1.34	-5.61	5.81	13.12	0.49	-73.64	-
	99%	0.729	0.30	-6.99	6.59	12.38	0.44	-77.69	-
	Max	0.834	-0.71	-8.73	11.62	20.77	0.54	-124.53	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ +$k_6\ T_{soil,30}/u$	Ave	0.710	1.52	-1.44	-1.39	-2.04	0.10	0.14	-
	98%	0.696	4.92	-5.90	-9.47	-11.41	0.13	0.77	-
	99%	0.679	7.37	-7.11	-11.25	-13.56	0.03	0.89	-
	Max	0.770	10.22	-9.09	-15.46	-20.75	-0.09	1.36	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ +$k_6\ P_{g,6h}\ T_{soil,30}$	Ave	0.779	0.28	-1.94	1.96	8.27	0.15	-0.58	-
	98%	0.742	-0.97	-8.22	8.28	21.87	0.38	-1.87	-
	99%	0.717	0.75	-9.71	9.18	19.69	0.32	-1.86	-
	Max	0.809	0.17	-13.04	15.73	28.35	0.35	-2.74	-
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ + $k_6/(H\ u)$+$k_7\ P_{g,6h}/u$	Ave	0.805	-0.40	25.56	2.23	6.55	0.19	-76.83	-25.33
	98%	0.795	-4.55	147.01	11.74	19.14	0.56	-439.47	-87.78
	99%	0.793	-3.68	181.56	13.92	19.81	0.52	-542.91	-95.15
	Max	0.875	-5.18	203.74	19.88	29.15	0.62	-611.79	-144.21
$k_1+k_2/H+k_3/u+k_4\ P_{g,6h}+k_5\ T_{soil,30}$ +$k_6\ P_{g,6h}\ T_{soil,30}$+$k_7\ P_{g,6h}/u$	Ave	0.787	0.18	-1.37	1.42	6.77	0.17	-0.19	-16.34
	98%	0.749	-1.30	-6.32	6.47	16.91	0.46	-0.58	-54.26
	99%	0.729	0.30	-7.06	6.66	12.77	0.43	-0.06	-75.71
	Max	0.836	-0.79	-7.39	10.36	13.61	0.58	1.09	-161.14

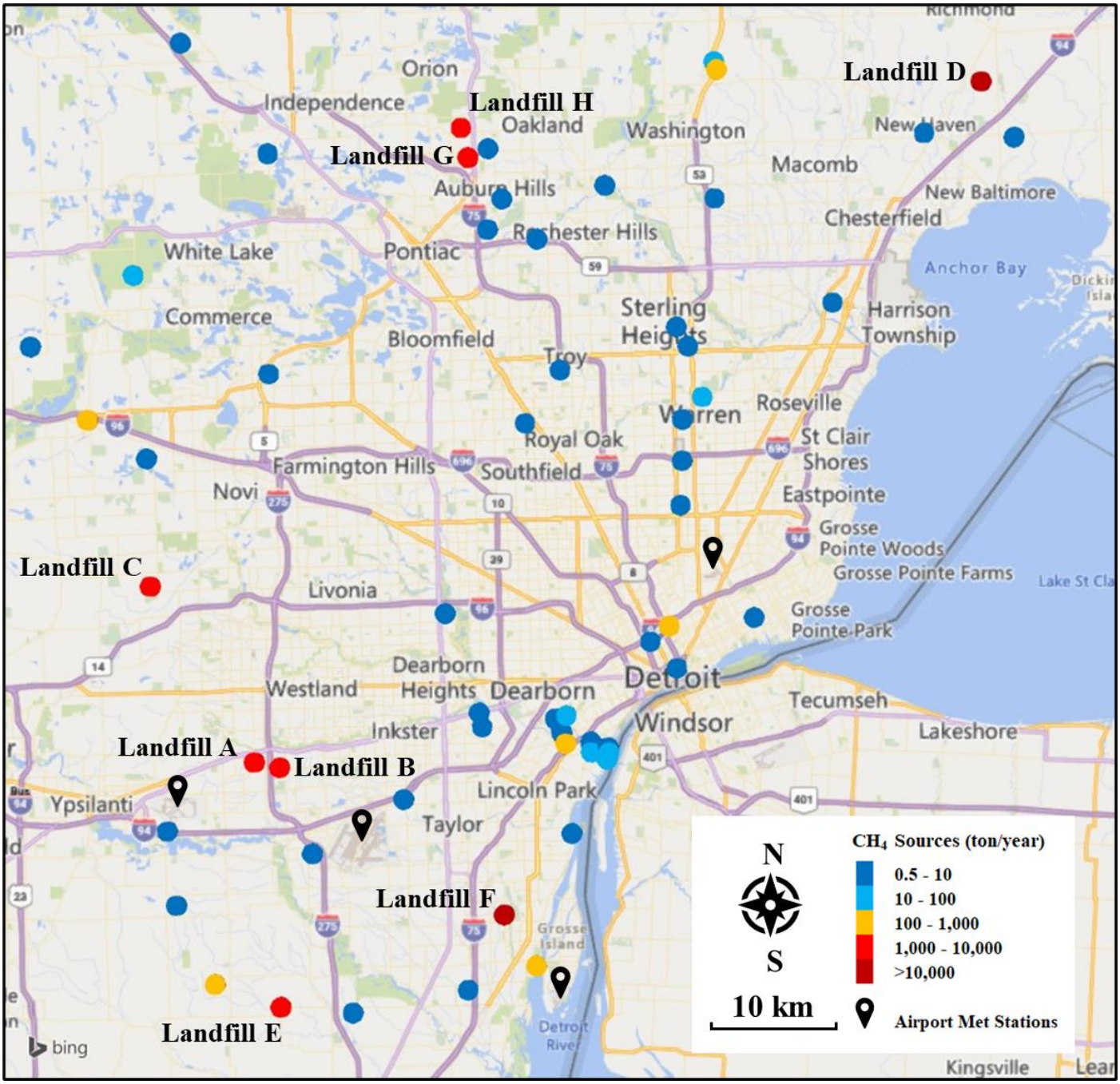


Figure S1. Map of eight visited landfills, four airport meteorological stations, and major CH_4 sources in southeast Michigan [3].

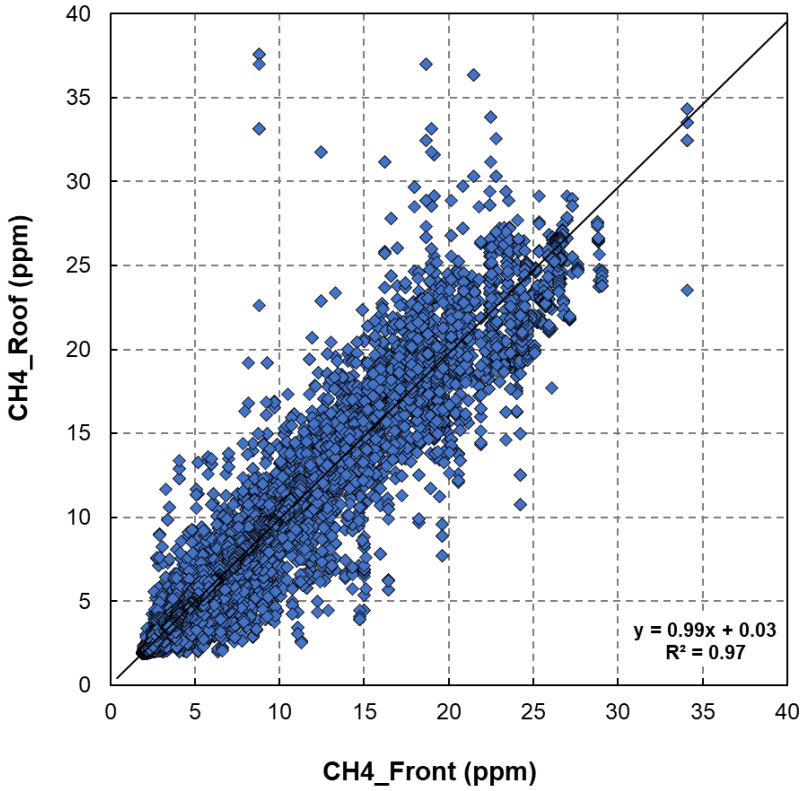


Figure S2. Comparison between the roof and front bumper inlet CH4 measurements.

All data were collected around the landfills 05/19/21 - 09/29/21. N=169,067; Averaging time = 1 s.

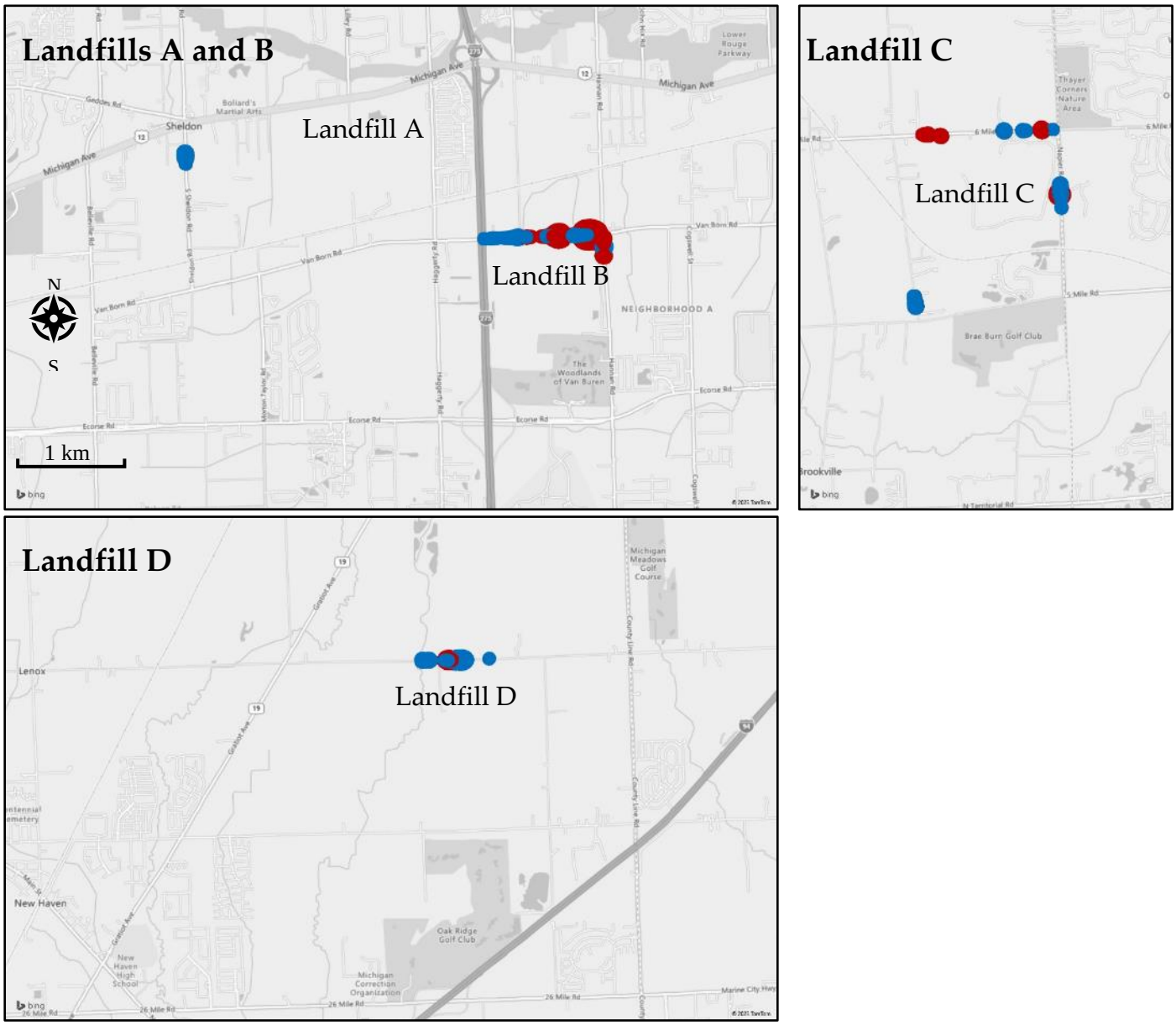


Figure S3. Locations where the roof and front bumper inlet measurements showed > 5 ppm difference.

Blue circles show roof measurements < near-ground measurements; Red circles show roof measurements > near-ground measurements. Circle size indicates size of concentration difference (5.0 to 28.8 ppm).

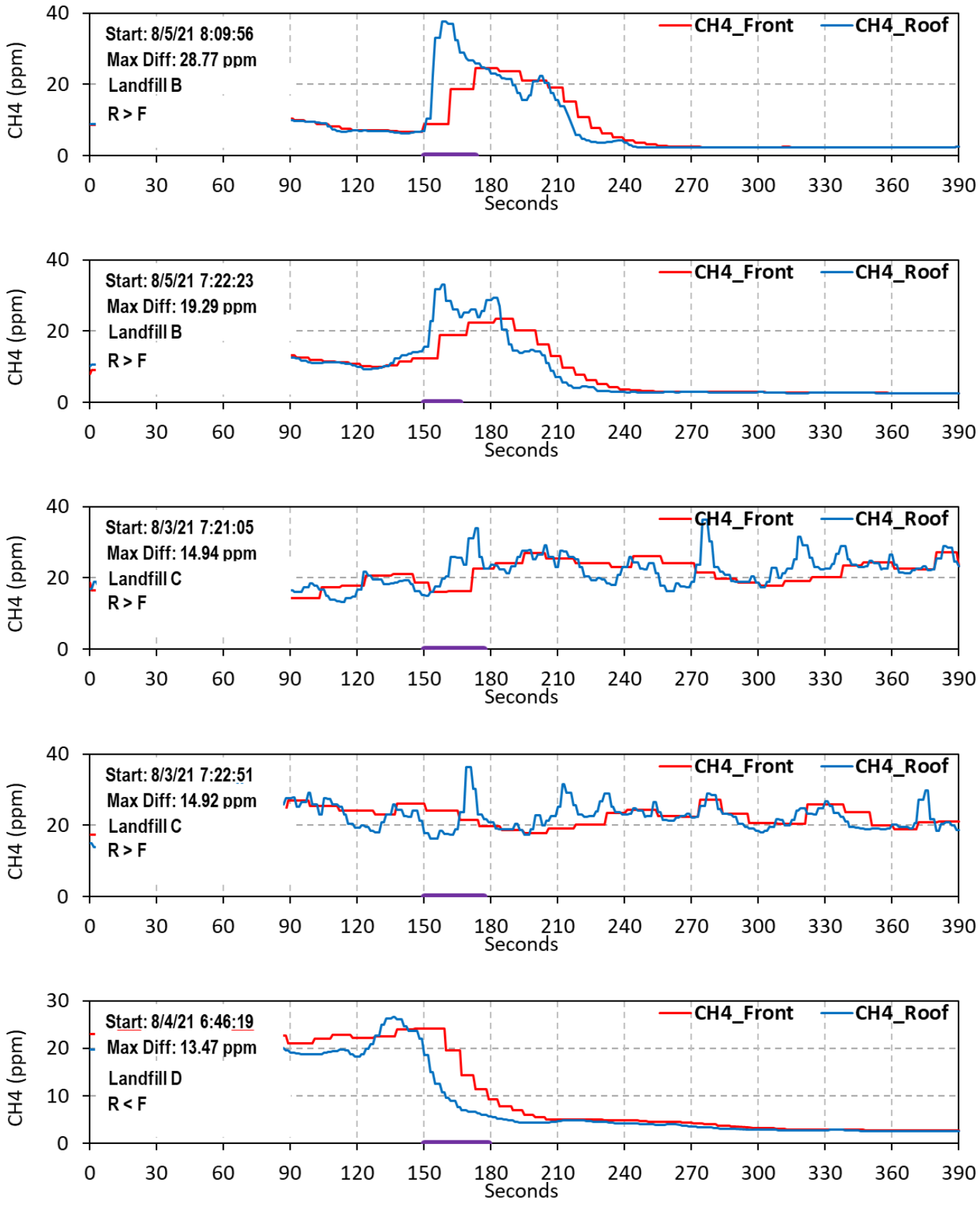
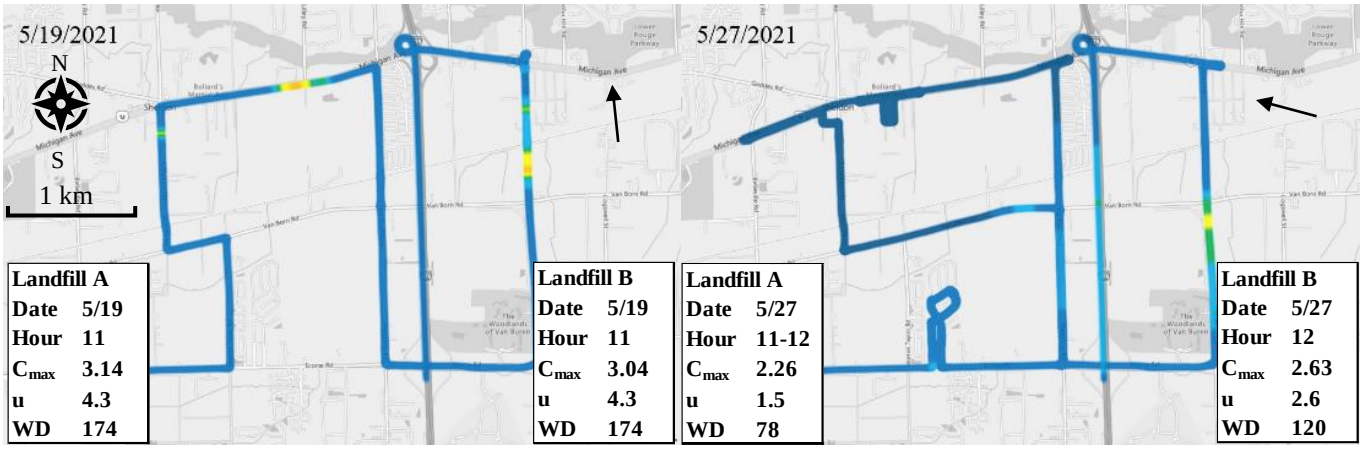


Figure S4. Trend plots of the five CH_4 peaks with the largest roof-top and near-ground measurement differences.

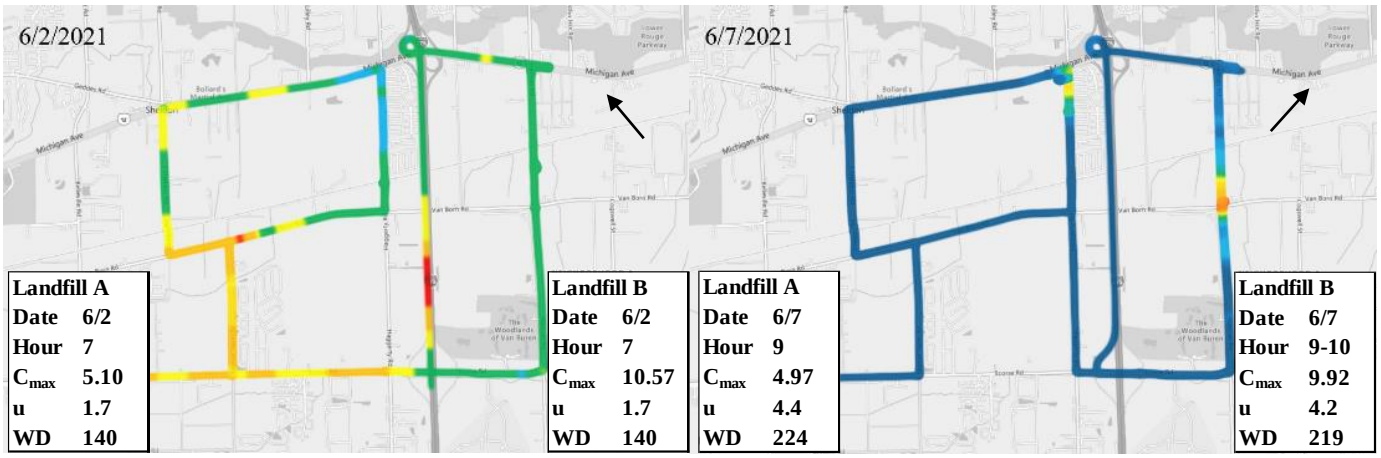


Landfill A	
Date	5/19
Hour	11
C_{max}	3.14
u	4.3
WD	174

Landfill B	
Date	5/19
Hour	11
C_{max}	3.04
u	4.3
WD	174

Landfill A	
Date	5/27
Hour	11-12
C_{max}	2.26
u	1.5
WD	78

Landfill B	
Date	5/27
Hour	12
C_{max}	2.63
u	2.6
WD	120

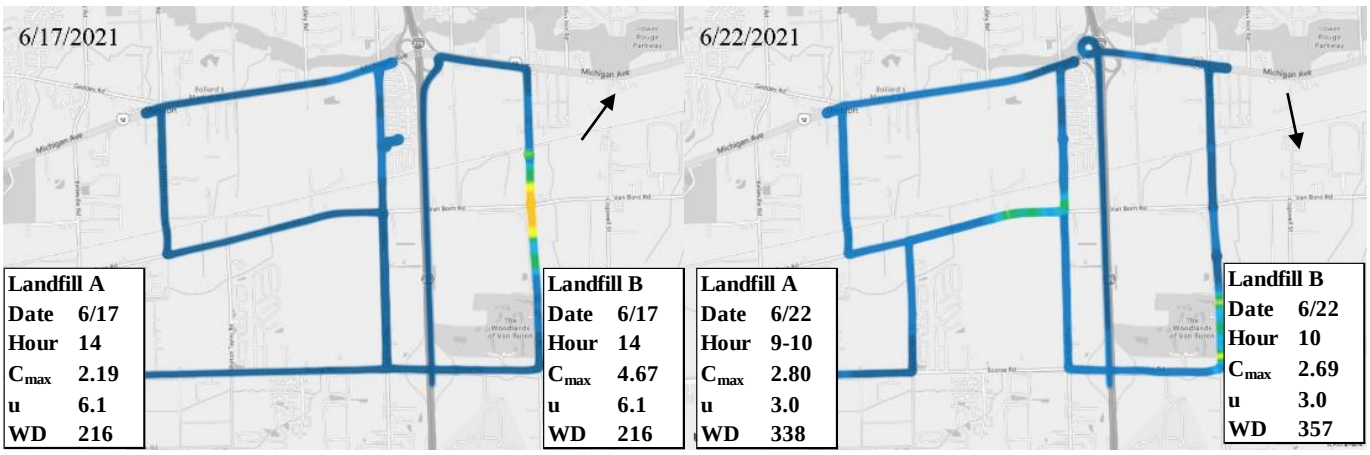


Landfill A	
Date	6/2
Hour	7
C_{max}	5.10
u	1.7
WD	140

Landfill B	
Date	6/2
Hour	7
C_{max}	10.57
u	1.7
WD	140

Landfill A	
Date	6/7
Hour	9
C_{max}	4.97
u	4.4
WD	224

Landfill B	
Date	6/7
Hour	9-10
C_{max}	9.92
u	4.2
WD	219



Landfill A	
Date	6/17
Hour	14
C_{max}	2.19
u	6.1
WD	216

Landfill B	
Date	6/17
Hour	14
C_{max}	4.67
u	6.1
WD	216

Landfill A	
Date	6/22
Hour	9-10
C_{max}	2.80
u	3.0
WD	338

Landfill B	
Date	6/22
Hour	10
C_{max}	2.69
u	3.0
WD	357

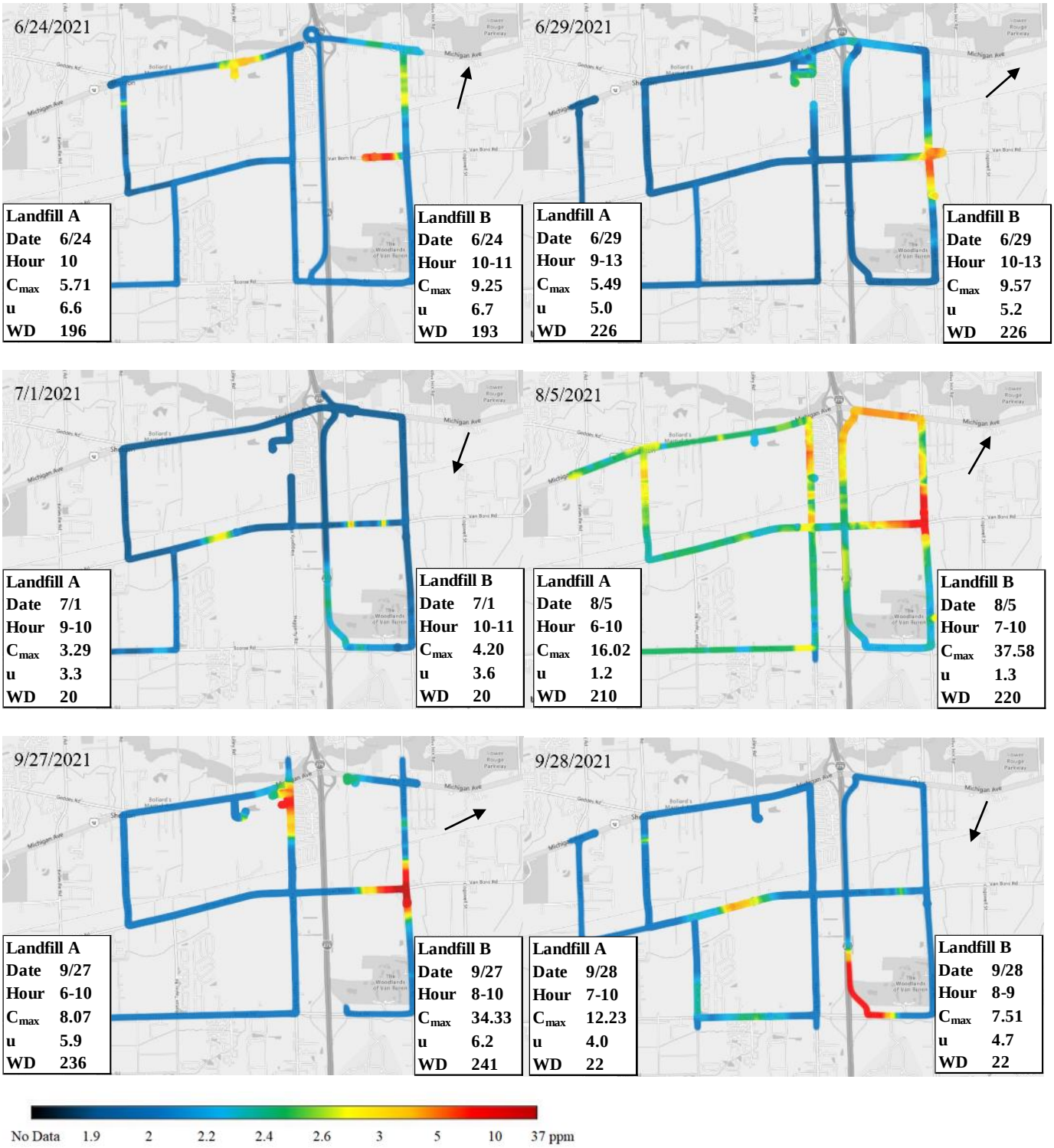
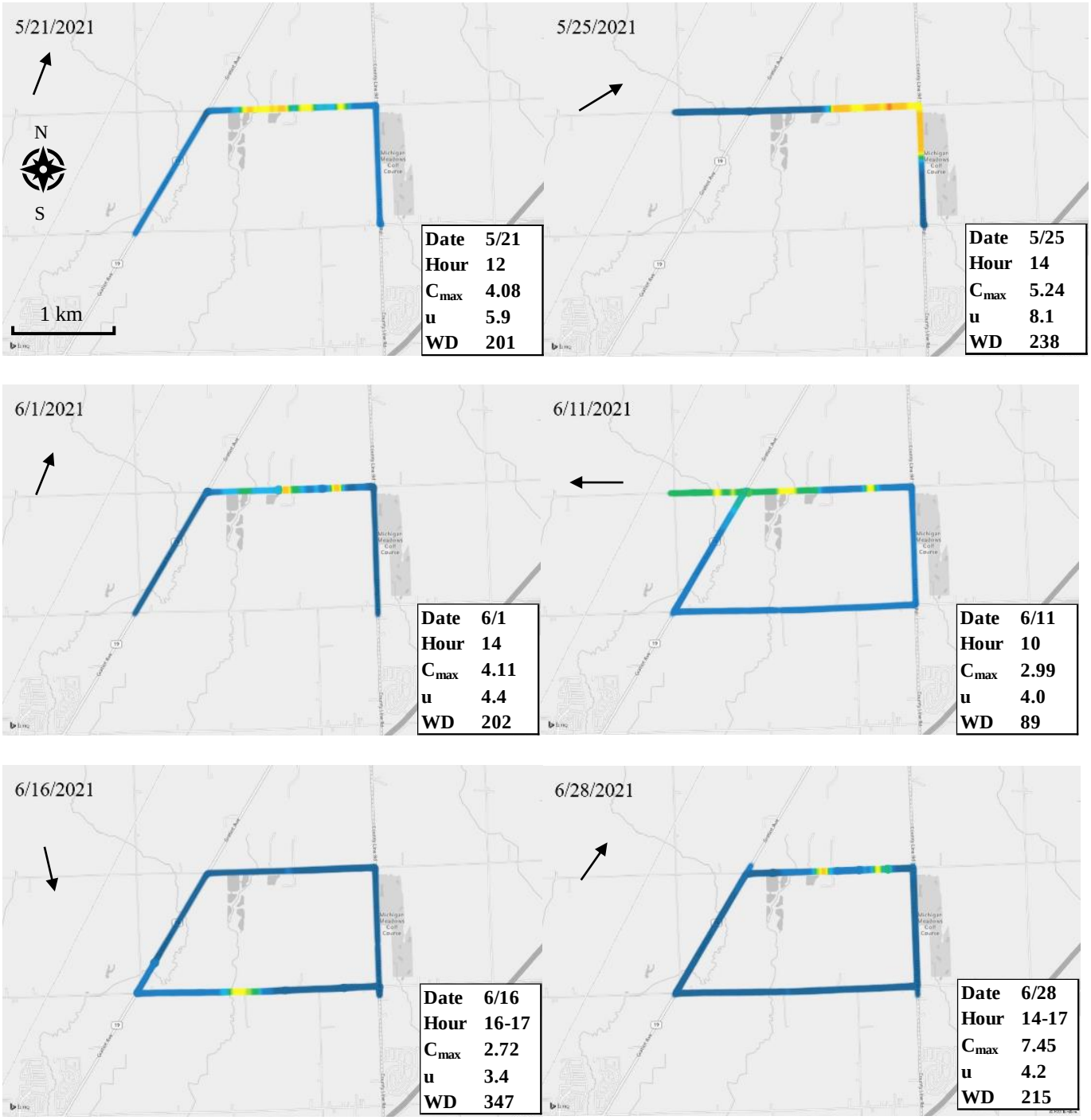


Figure S5. Maps of daily CH_4 concentration measured at Landfills A and B. Arrow indicates the dominant wind direction. Date, hour-of-day, maximum concentration (C_{max}, ppm), wind speed (u, m/s) and dominant wind direction (WD, °) are listed for each map.


5/21/2021
N
S
1 km
Date 5/21
Hour 12
Cmax 4.08
u 5.9
WD 201
5/25/2021
Date 5/25
Hour 14
Cmax 5.24
u 8.1
WD 238
6/1/2021
Date 6/1
Hour 14
Cmax 4.11
u 4.4
WD 202
6/11/2021
Date 6/11
Hour 10
Cmax 2.99
u 4.0
WD 89
6/16/2021
Date 6/16
Hour 16-17
Cmax 2.72
u 3.4
WD 347
6/28/2021
Date 6/28
Hour 14-17
Cmax 7.45
u 4.2
WD 215

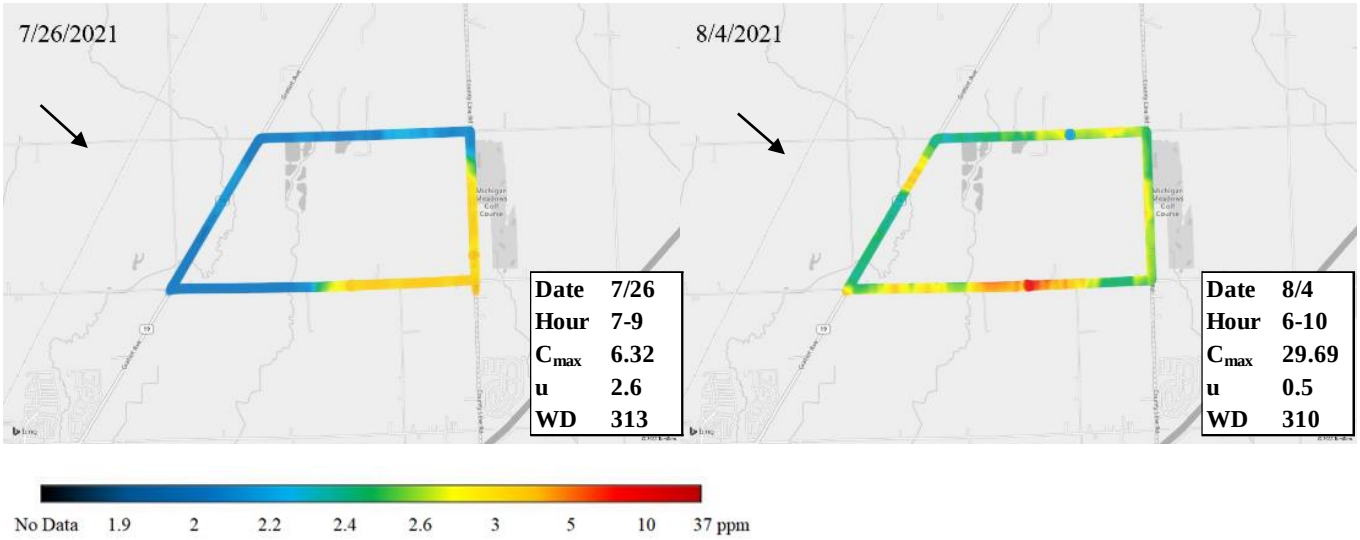


Figure S6. Maps of daily CH_4 concentration measured at Landfill D.

Arrow indicates the dominant wind direction. Date, hour-of-day, maximum concentration (C_{max}, ppm), wind speed (u, m/s) and dominant wind direction (WD, °) are listed for each map.

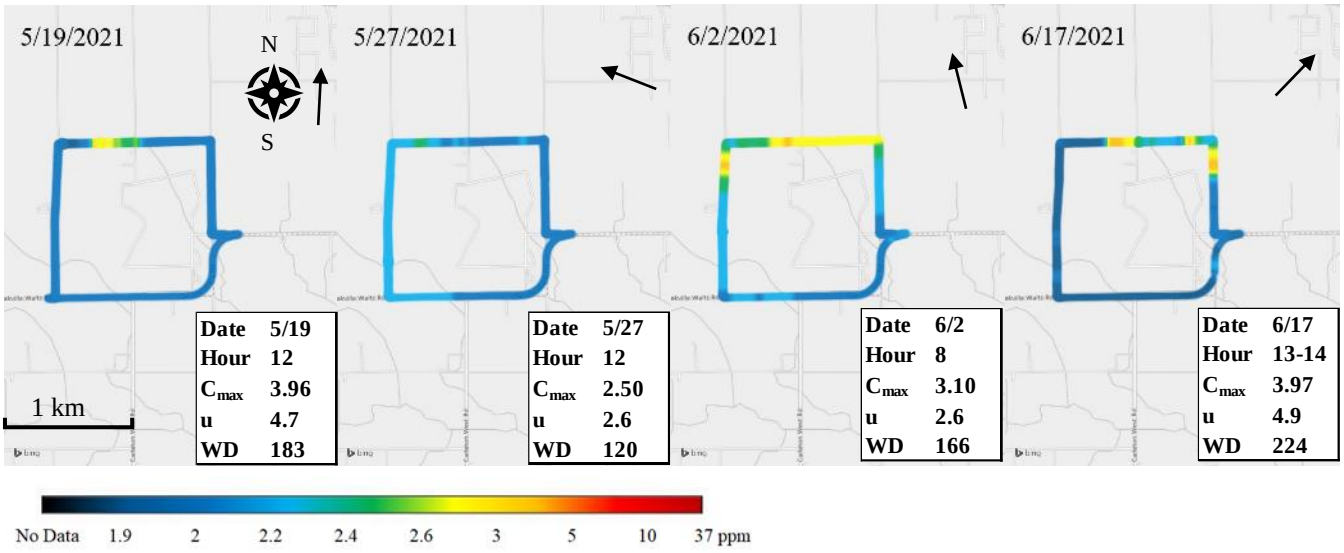


Figure S7. Maps of daily CH_4 concentration measured at Landfill E.

Arrow indicates the dominant wind direction. Date, hour-of-day, maximum concentration (C_{max}, ppm), wind speed (u, m/s) and dominant wind direction (WD, °) are listed for each map.

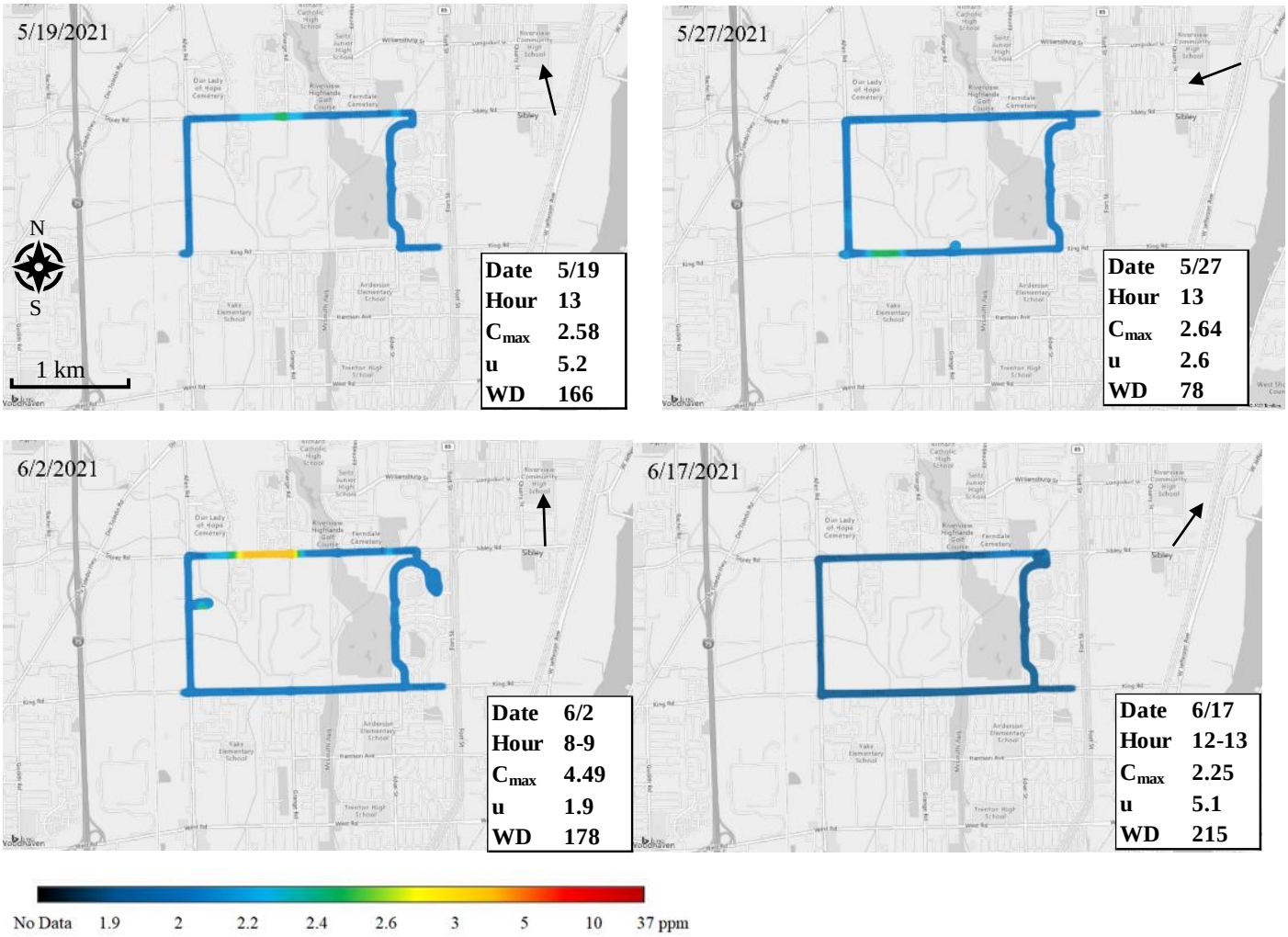
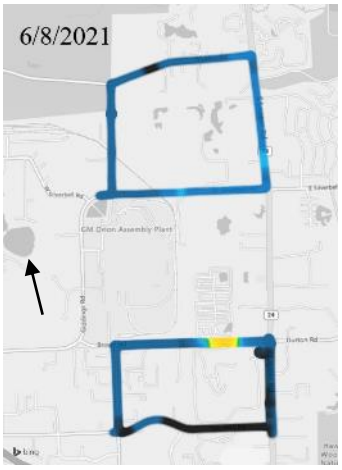


Figure S8. Maps of daily CH_4 concentration measured at Landfill F.

Arrow indicates the dominant wind direction. Date, hour-of-day, maximum concentration (C_{max}, ppm), wind speed (u, m/s) and dominant wind direction (WD, °) are listed for each map.

Landfill G		Landfill H	
Date	5/25	Date	5/25
Hour	12	Hour	12
C_{max}	4.36	C_{max}	2.72
u	7.8	u	7.8
WD	237	WD	237

Landfill G		Landfill H	
Date	6/5	Date	6/5
Hour	8-9	Hour	8-9
C_{max}	4.69	C_{max}	3.01
u	5.6	u	5.8
WD	248	WD	248



Landfill G		Landfill H	
Date	6/8	Date	6/8
Hour	13	Hour	13
C_{max}	3.98	C_{max}	2.26
u	3.5	u	3.5
WD	166	WD	166

Landfill G		Landfill H	
Date	6/9	Date	6/9
Hour	15-16	Hour	15-16
C_{max}	2.48	C_{max}	4.53
u	2.8	u	2.8
WD	123	WD	123

Landfill G		Landfill H	
Date	6/16	Date	6/16
Hour	11-12	Hour	12
C_{max}	2.26	C_{max}	4.61
u	3.7	u	3.6
WD	358	WD	1

Figure S9. Maps of daily CH_4 concentration measured at Landfills G and H.

Arrow indicates the dominant wind direction. Date, hour-of-day, maximum concentration (C_{max}, ppm), wind speed (u, m/s) and dominant wind direction (WD, °) are listed for each map.

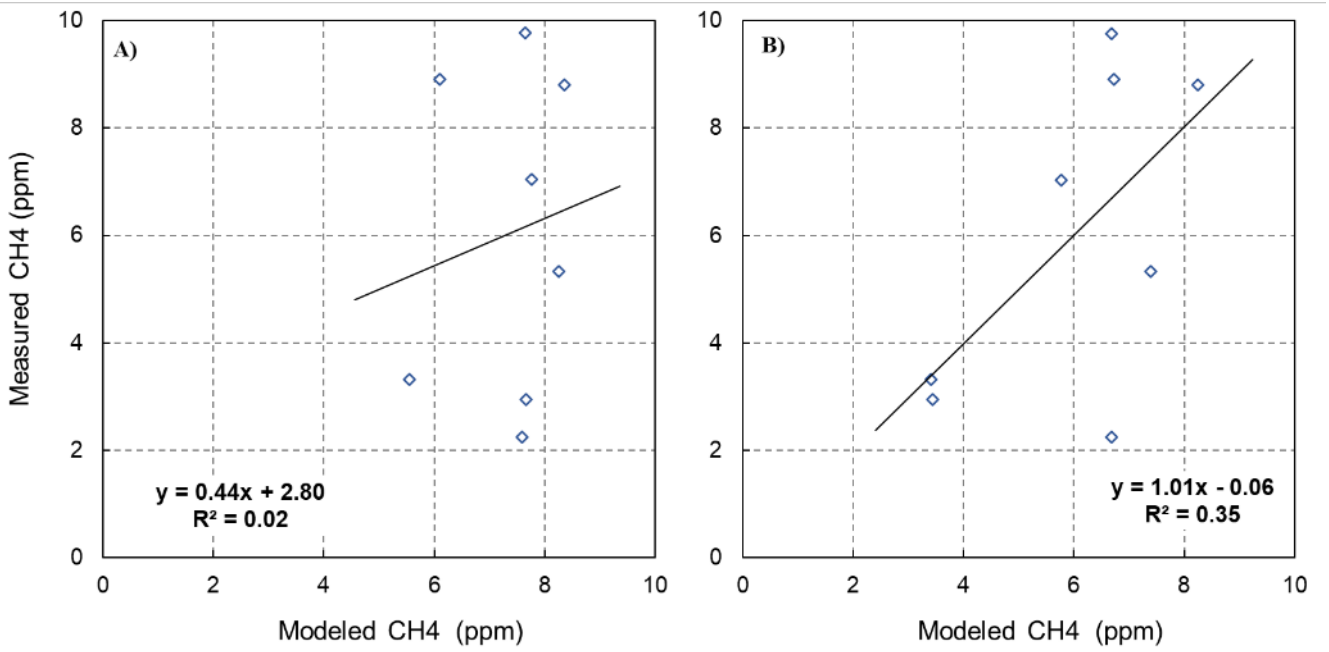


Figure S10. Scatter plots of measured CH_4 daily maximum concentrations (< 10 ppm) against the modeled value calculated with a) Model 6 and b) Eq. S4 optimized by the GRG nonlinear method.

Eq. S4:

$$C_{max} = -3.5 + \frac{1.26 \times 10^7}{(1.48 \times 10^5 + H)(5.55 + u)} \quad \text{(S4)}$$

References

1. Czepiel, P.M.; Shorter, J.H.; Mosher, B.; Allwine, E.; McManus, J.B.; Harriss, R.C.; Kolb, C.E.; Lamb, B.K. The Influence of Atmospheric Pressure on Landfill Methane Emissions. *Waste Manag.* **2003**, *23*, 593–598, doi:10.1016/S0956-053X(03)00103-X.
2. Chen, H.; Zhu, T.; Li, B.; Fang, C.; Nie, M. The Thermal Response of Soil Microbial Methanogenesis Decreases in Magnitude with Changing Temperature. *Nat. Commun.* **2020**, *11*, 5733, doi:10.1038/s41467-020-19549-4.
3. US EPA, O. 2017 National Emissions Inventory (NEI) Data Available online: https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data (accessed on 7 May 2023).