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High-resolution US methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills

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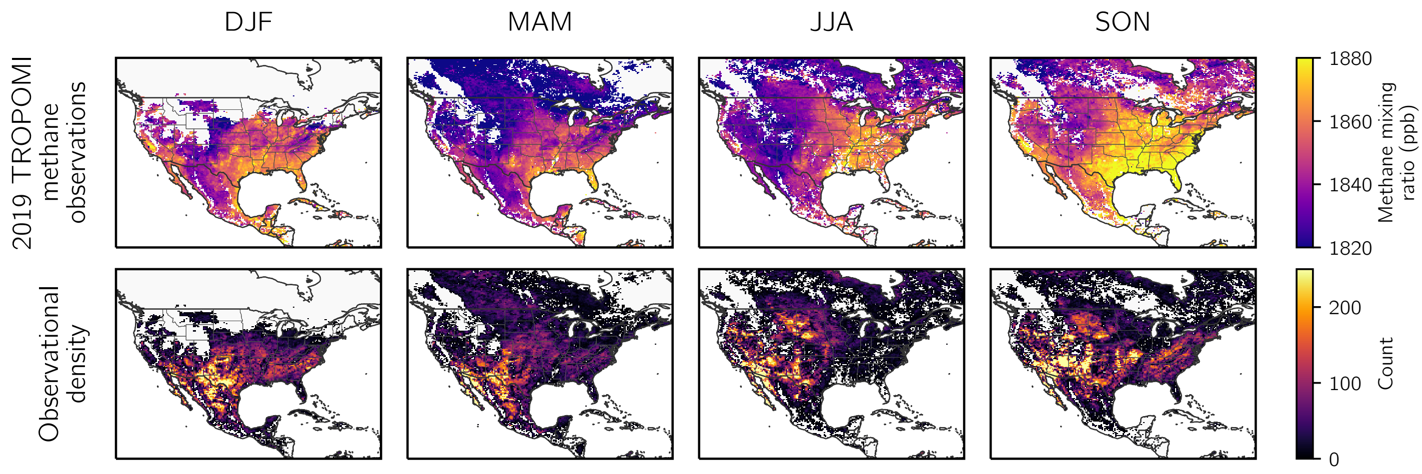

Figure S1: Seasonality of the TROPOMI methane data in 2019. The top row shows the seasonal average column dry methane mixing ratios for 2019 averaged on the 0.25° × 0.3125° GEOS-Chem grid. The bottom row shows the number of observations for each season on the same grid. Column titles give the season. The observations have been filtered as described in Sect. 2.4.

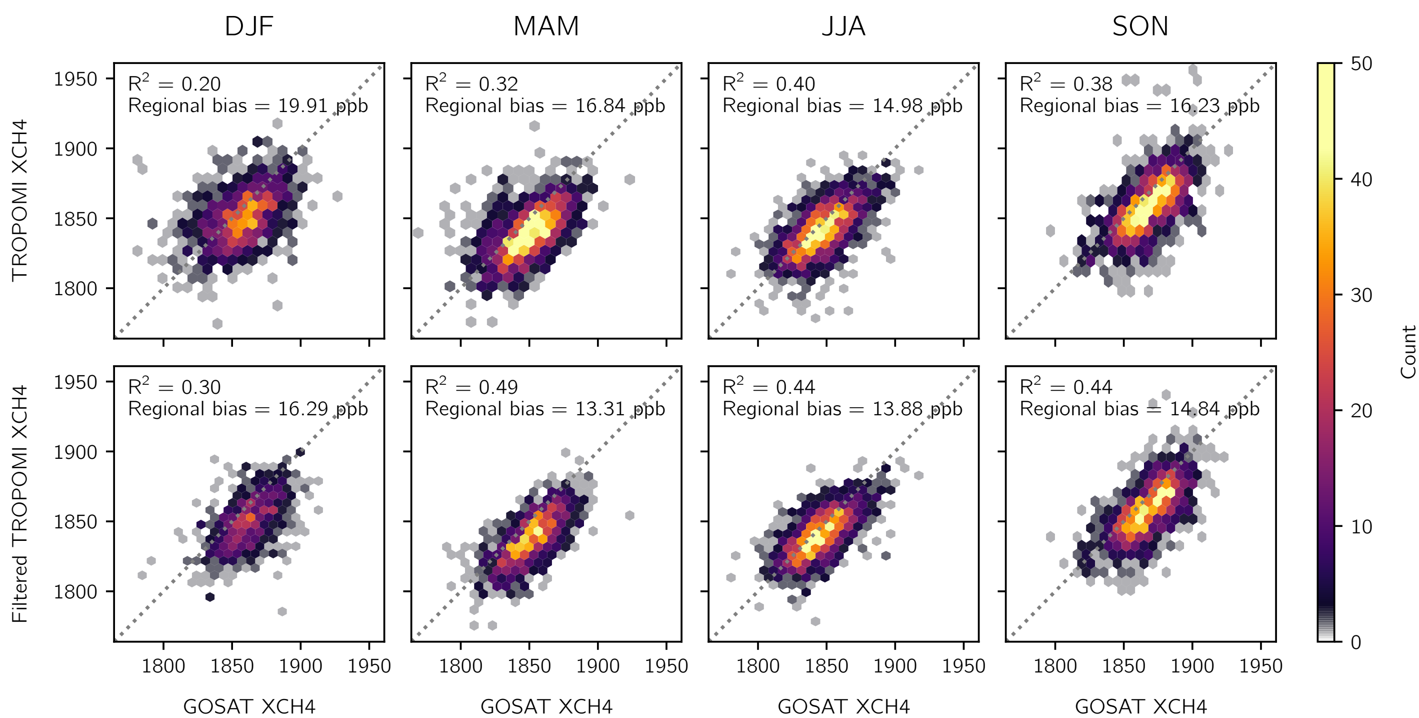

Figure S2: Evaluation of the TROPOMI methane data with GOSAT observations. Each panel shows the TROPOMI data (y-axis) plotted against the GOSAT observations (x-axis), each averaged on a 2° × 2° grid over the North America domain (Figure 2). Data density is shown instead of individual points. Columns show data for each season. The top row shows the unfiltered TROPOMI data with only the standard quality assessment filter applied. The bottom row shows the filtered TROPOMI data that removes observations over scenes that are likely snow- and ice-covered following Section 2.4. Inset are the squared Pearson correlation coefficient (R^2) and the regional bias defined as the standard deviation of the grid-cell-to-grid-cell bias.

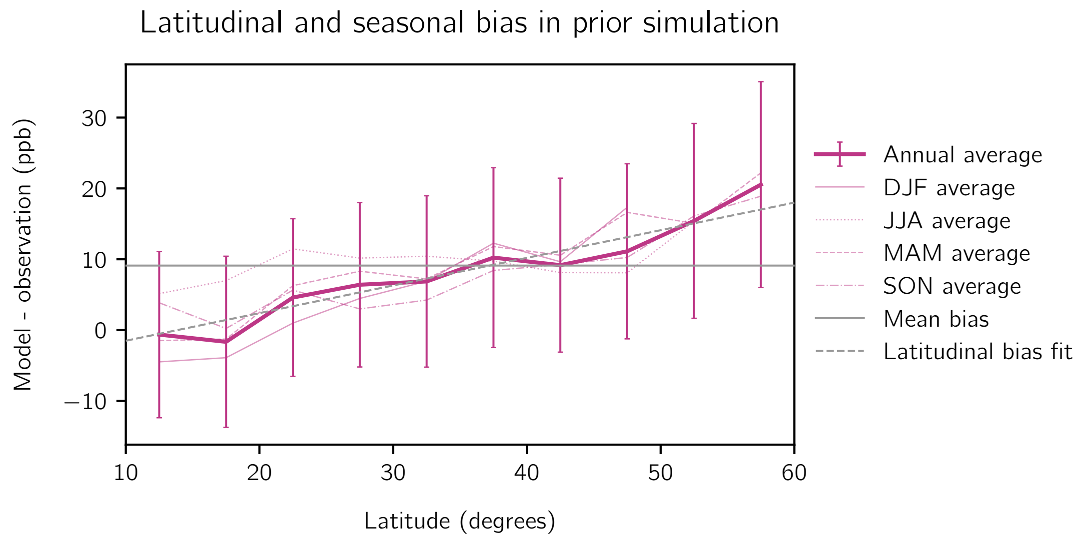

Figure S3: Quantification of (GEOS-Chem - TROPOMI) biases in a simulation run with the prior emissions. The bold line shows the annual mean (GEOS-Chem - TROPOMI) difference by latitude, with error bars given by the one standard deviation range. Light lines show the (GEOS-Chem - TROPOMI) difference averaged seasonally. Grey lines give the mean bias ($\boldsymbol{\xi} = 9.11$ ppb) and the latitudinal bias fit ($\boldsymbol{\xi} = \mathbf{-5.40 + 0.39\theta}$, where $\boldsymbol{\theta}$ is the degrees latitude) used as corrections to the (model - observation) difference in the eight-member inversion ensemble.

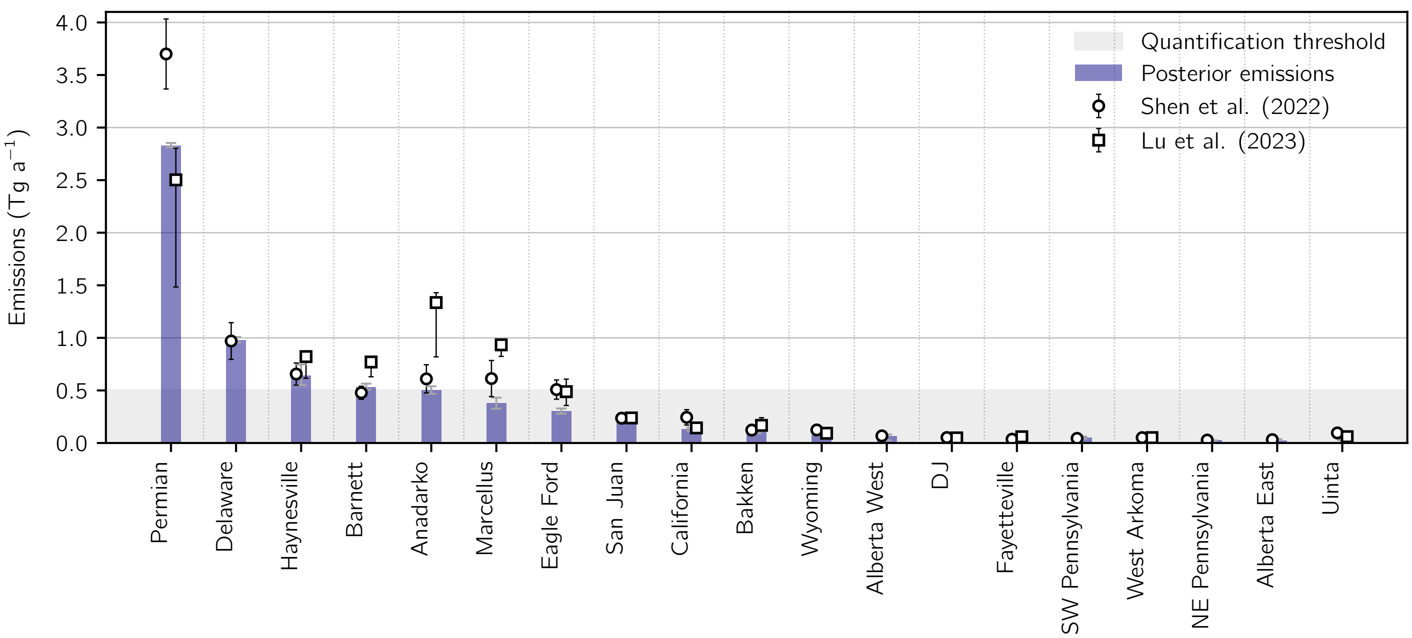

Figure S4: Methane emissions from the TROPOMI inversion for the oil and gas sector for individual basins across North America for 2019. Basin boundaries are defined following Shen et al. (2022) and Lu et al. (2023). The posterior emissions are shown as bars, with error bars are given by the eight-member ensemble range. Also shown are basin estimates and error bars from Shen et al. (2022) and Lu et al. (2023) and the 0.5 Tg a^{-1} threshold for successful emission quantification from Shen et al. (2022).

Table S1 (page 1 of 2): Methane emissions from the 48 states in the contiguous United States for 2019.

Emissions (Gg a^{-1})[1]	Livestock		Oil and gas		Coal		Landfills		Wastewater		Other anthropogenic		Total		
State	**GHGI**[2]	**$\hat{x}$**[3]	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**[4]	**DOFS**[5]
1. Texas	1023	1165	2270	4299	9	24	513	627	61	48	94	110	3970	6274 (6101, 6454)	0.94 (0.89, 0.97)
2. California	760	1104	231	231	0	0	356	514	59	58	218	148	1623	2055 (1970, 2122)	0.86 (0.75, 0.93)
3. Oklahoma	380	399	763	894	3	20	86	121	9	3	7	6	1248	1444 (1384, 1511)	0.86 (0.75, 0.92)
4. Pennsylvania	199	196	777	238	498	524	110	196	24	20	22	20	1629	1194 (1061, 1384)	0.57 (0.35, 0.77)
5. New Mexico	170	211	487	925	28	32	34	-34	4	2	6	3	729	1139 (1100, 1180)	0.96 (0.93, 0.98)
6. Louisiana	62	79	628	731	1	2	133	126	10	9	119	174	951	1121 (1010, 1258)	0.55 (0.28, 0.76)
7. Iowa	555	793	57	59	0	0	65	116	24	13	6	7	707	989 (952, 1010)	0.75 (0.54, 0.88)
8. Illinois	160	191	140	121	126	170	162	368	25	37	17	21	630	907 (862, 944)	0.55 (0.29, 0.79)
9. Florida	155	250	56	26	0	0	313	540	38	15	22	47	584	878 (699, 1106)	0.32 (0.04, 0.58)
10. Kansas	490	448	429	358	0	0	55	41	19	9	5	3	999	860 (839, 888)	0.80 (0.66, 0.89)
11. Colorado	263	232	465	351	65	102	74	110	14	4	10	5	891	804 (740, 861)	0.59 (0.44, 0.72)
12. Michigan	182	187	127	121	0	0	197	392	23	19	28	22	557	742 (674, 813)	0.49 (0.16, 0.74)
13. Alabama	102	109	108	120	183	154	169	259	19	25	10	11	592	677 (629, 717)	0.75 (0.55, 0.89)
14. North Carolina	266	375	41	23	0	0	187	225	32	17	12	13	538	654 (547, 744)	0.48 (0.24, 0.71)
15. Ohio	165	146	327	160	30	32	189	244	19	24	18	16	747	622 (578, 673)	0.63 (0.38, 0.82)
16. Indiana	140	170	83	60	132	79	117	274	15	17	13	16	500	616 (561, 676)	0.54 (0.28, 0.74)
17. Nebraska	531	533	45	24	0	0	47	46	22	5	4	3	650	611 (604, 619)	0.64 (0.48, 0.73)
18. West Virginia	28	26	298	182	579	360	30	32	4	2	5	4	944	607 (485, 730)	0.66 (0.46, 0.83)
19. Arkansas	124	122	169	134	0	13	66	106	16	10	233	218	607	605 (569, 636)	0.74 (0.48, 0.86)
20. Georgia	114	127	51	47	0	0	258	374	30	9	14	18	466	575 (509, 655)	0.58 (0.35, 0.73)
21. Wisconsin	424	407	47	16	0	0	85	114	17	8	17	14	589	559 (518, 595)	0.47 (0.07, 0.70)
22. Idaho	316	317	13	11	0	0	20	219	5	2	8	3	363	551 (498, 596)	0.63 (0.49, 0.76)
23. Minnesota	295	381	48	26	0	0	54	83	18	4	16	10	430	504 (475, 534)	0.53 (0.13, 0.69)
24. Mississippi	77	104	91	132	3	6	74	134	13	24	40	23	298	423 (380, 478)	0.53 (0.22, 0.75)
25. New York	230	139	139	47	0	0	109	154	30	43	27	23	534	405 (352, 445)	0.30 (0.06, 0.50)

Table S1 (page 2 of 2): Methane emissions from the 48 states in the contiguous United States for 2019.

Emissions (Gg a⁻¹)[1]	Livestock		Oil and gas		Coal		Landfills		Wastewater		Other anthropogenic		Total		
State	**GHGI[2]**	**$\hat{x}$[3]**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$**	**GHGI**	**$\hat{x}$[4]**	**DOFS[5]**
26. Kentucky	154	143	115	68	61	69	160	105	13	4	9	7	512	395 (347, 449)	0.64 (0.40, 0.82)
27. South Dakota	332	347	12	12	0	0	11	18	5	12	2	2	362	392 (376, 401)	0.38 (0.11, 0.53)
28. Missouri	331	266	41	14	0	0	65	54	16	9	44	24	498	367 (339, 394)	0.55 (0.29, 0.69)
29. Virginia	112	109	79	31	153	20	138	169	21	22	14	11	517	362 (299, 428)	0.56 (0.35, 0.75)
30. Tennessee	132	122	53	40	2	2	116	132	15	20	10	7	327	322 (301, 349)	0.60 (0.33, 0.77)
31. Montana	215	211	76	63	20	10	13	19	2	1	8	3	333	306 (292, 322)	0.31 (0.22, 0.40)
32. North Dakota	136	124	143	141	5	6	18	26	2	2	3	2	307	300 (286, 317)	0.59 (0.41, 0.70)
33. Washington	147	149	26	20	0	0	71	98	18	14	21	13	284	293 (269, 337)	0.10 (0.04, 0.14)
34. Utah	92	105	129	49	28	79	32	49	6	0	5	3	292	285 (248, 336)	0.74 (0.57, 0.87)
35. Oregon	115	132	24	23	0	0	56	111	8	3	14	8	217	276 (256, 304)	0.08 (0.05, 0.11)
36. Arizona	121	141	49	41	1	2	70	72	11	4	6	3	259	263 (261, 266)	0.80 (0.74, 0.84)
37. South Carolina	37	53	26	11	0	0	68	145	13	21	8	8	153	237 (220, 249)	0.51 (0.20, 0.70)
38. New Jersey	4	4	45	51	0	0	58	116	13	35	11	27	131	233 (186, 294)	0.28 (0.06, 0.52)
39. Maryland	23	28	19	20	2	4	45	57	13	4	8	7	110	120 (112, 126)	0.26 (0.04, 0.45)
40. Nevada	45	49	20	9	0	0	17	30	4	2	3	2	89	93 (93, 93)	0.00 (0.00, 0.00)
41. Massachusetts	4	4	29	17	0	0	25	48	11	4	9	7	79	80 (66, 93)	0.15 (0.00, 0.35)
42. Wyoming	109	113	302	142	200	-186	6	10	1	0	3	1	623	80 (-194, 279)	0.68 (0.48, 0.86)
43. Vermont	38	29	1	0	0	0	7	13	2	1	6	3	53	46 (45, 49)	0.02 (0.00, 0.07)
44. Connecticut	8	5	13	8	0	0	8	15	6	12	5	4	40	45 (35, 51)	0.26 (0.01, 0.50)
45. Maine	11	10	4	2	0	0	13	20	5	1	10	6	42	38 (37, 39)	0.00 (0.00, 0.00)
46. New Hampshire	4	5	3	1	0	0	21	16	4	1	6	3	38	25 (23, 27)	0.03 (0.00, 0.08)
47. Delaware	3	4	5	2	0	0	17	8	5	5	1	2	32	20 (19, 22)	0.12 (0.04, 0.23)
48. Rhode Island	0	1	5	4	0	0	6	11	2	2	2	1	16	18 (14, 21)	0.19 (0.07, 0.34)

[1]Sectoral emissions in gigagrams per year (Gg a^{-1}) for anthropogenic sources.

[2]Bottom-up emissions for each state from the 2023 EPA GHGI state estimates for 2019.

[3]Optimized sectoral anthropogenic emissions from an inversion of TROPOMI data for 2019.

[4]The total anthropogenic optimized emissions. Values in parentheses give the minimum and maximum of the ensemble of 8 inversions.

[5]The sensitivity of the total state posterior emissions to the observing system, given by the diagonal elements of the state averaging kernel matrix calculated. Values in parentheses give the ensemble range. Sensitivities range from 0 (unresponsive to the observing system) to 1 (fully responsive).

Table S2 (page 1 of 4): Methane emissions from urban areas in the contiguous U.S. (CONUS) for 2019.

Urban area[1]	Spatially allocated GHGI emissions (Gg a^{-1})[2]						Posterior emissions	
	Landfills	Wastewater	Post-meter gas	Gas distribution	Other anthropogenic	Total	Total (Gg a^{-1})[3]	Sensitivity[4]
1. New York--Newark, NY--NJ--CT	68.4	42.2	27.3	37.8	37.5	213.2	309 (241, 417)	0.28 (0.04, 0.54)
2. Detroit, MI	56.6	6.4	5.6	8.8	16.2	93.6	210 (170, 259)	0.33 (0.14, 0.55)
3. Atlanta, GA	53.8	3.1	6.7	4.6	26.8	95	179 (157, 208)	0.50 (0.33, 0.65)
4. Dallas--Fort Worth--Arlington, TX	69.3	12.3	7.6	17.4	145.1	251.7	362 (337, 384)	0.52 (0.34, 0.70)
5. Houston, TX	44.9	5.7	7.4	15.3	69.6	142.9	209 (183, 236)	0.36 (0.21, 0.51)
6. Chicago, IL--IN	74.3	22.7	12.8	15.9	32.7	158.4	207 (190, 224)	0.38 (0.18, 0.58)
7. Los Angeles--Long Beach--Anaheim, CA	112.5	12.7	18.1	14.7	30.3	188.3	121 (116, 127)	0.76 (0.62, 0.88)
8. Cincinnati, OH--KY--IN	41.8	12.8	2.4	3.5	8.4	68.9	98 (85, 109)	0.48 (0.22, 0.74)
9. Miami, FL	73.3	9.0	8.2	2.8	12.4	105.7	284 (206, 395)	0.24 (0.06, 0.44)
10. Philadelphia, PA--NJ--DE--MD	31.8	10.9	8.1	14.8	30.2	95.8	122 (108, 132)	0.24 (0.07, 0.43)
11. Indianapolis, IN	22.4	1.5	2.2	3.6	16.3	46	101 (84, 127)	0.34 (0.13, 0.60)
12. Denver--Aurora, CO	42.3	2.0	3.5	5.8	29.2	82.8	96 (76, 119)	0.59 (0.43, 0.73)
13. Reading, PA	11.4	0.3	0.4	1.0	16.3	29.4	104 (66, 158)	0.38 (0.15, 0.64)
14. Memphis, TN--MS--AR	20.1	8.1	1.6	1.4	15.9	47.1	81 (70, 96)	0.49 (0.26, 0.71)
15. Birmingham, AL	31.5	5.7	1.1	2.1	83.4	123.8	248 (201, 310)	0.50 (0.28, 0.74)
16. Austin, TX	23.1	1.1	2.0	4.3	10.0	40.5	67 (58, 82)	0.53 (0.32, 0.75)
17. Fort Wayne, IN	7.9	0.5	0.5	0.8	5.3	15	58 (45, 74)	0.31 (0.16, 0.50)
18. San Diego, CA	21.3	2.8	4.4	3.0	5.8	37.3	46 (43, 48)	0.73 (0.56, 0.88)
19. Davenport, IA--IL	11.9	0.5	0.4	0.7	8.6	22.1	57 (48, 72)	0.23 (0.11, 0.37)
20. Rockford, IL	21.1	0.5	0.4	0.8	5.6	28.4	49 (34, 54)	0.33 (0.13, 0.58)
21. Corpus Christi, TX	16.8	0.8	0.5	1.2	22.2	41.5	79 (60, 117)	0.21 (0.10, 0.34)
22. Peoria, IL	15.0	0.5	0.4	0.6	4.4	20.9	49 (43, 55)	0.22 (0.10, 0.33)
23. San Francisco--Oakland, CA	24.5	13.8	4.9	3.5	14.3	61	69 (59, 87)	0.30 (0.16, 0.44)
24. San Antonio, TX	22.2	6.2	2.6	5.4	20.2	56.6	51 (38, 63)	0.33 (0.22, 0.44)
25. Sacramento, CA	25.7	2.0	2.6	2.3	30.2	62.8	67 (64, 71)	0.53 (0.33, 0.71)
26. Charlotte, NC--SC	14.7	1.1	1.9	0.9	13.9	32.5	50 (42, 59)	0.39 (0.21, 0.56)
27. Minneapolis--St. Paul, MN--WI	15.9	2.2	4.0	4.4	17.5	44	53 (42, 70)	0.23 (0.07, 0.34)
28. Phoenix--Mesa, AZ	28.9	2.4	5.4	2.1	23.8	62.6	43 (40, 47)	0.79 (0.67, 0.88)
29. El Paso, TX--NM	7.1	2.1	1.2	1.5	5.2	17.1	15 (13, 18)	0.45 (0.33, 0.53)

Table S2 (page 2 of 4): Methane emissions from urban areas in the contiguous U.S. (CONUS) for 2019.

Urban area[1]	Spatially allocated GHGI emissions (Gg a^{-1})[2]						Posterior emissions	
	Landfills	Wastewater	Post-meter gas	Gas distribution	Other anthropogenic	Total	Total (Gg a^{-1})[3]	Sensitivity[4]
30. Oklahoma City, OK	17.4	0.7	1.3	3.7	19.0	42.1	59 (49, 71)	0.53 (0.30, 0.75)
31. Riverside--San Bernardino, CA	14.6	2.5	2.9	2.2	13.1	35.3	40 (39, 42)	0.43 (0.32, 0.54)
32. Montgomery, AL	8.6	4.3	0.4	0.7	5.7	19.7	32 (27, 37)	0.20 (0.10, 0.31)
33. Stockton, CA	7.3	2.8	0.6	0.6	17.5	28.8	57 (47, 68)	0.25 (0.14, 0.39)
34. San Jose, CA	12.2	4.4	2.5	1.8	2.7	23.6	26 (24, 32)	0.31 (0.17, 0.47)
35. Tulsa, OK	14.3	0.6	1.0	3.0	13.4	32.3	36 (28, 43)	0.39 (0.24, 0.54)
36. Youngstown, OH--PA	16.2	0.7	0.6	1.4	25.2	44.1	55 (48, 63)	0.42 (0.21, 0.63)
37. Grand Rapids, MI	14.0	0.6	0.8	2.1	18.5	36	45 (41, 52)	0.22 (0.05, 0.33)
38. Tuscaloosa, AL	11.8	0.2	0.2	0.4	22.2	34.8	55 (45, 69)	0.50 (0.27, 0.74)
39. Lancaster, PA	4.2	0.6	0.6	1.5	22.6	29.5	64 (51, 78)	0.31 (0.15, 0.47)
40. Pittsburgh, PA	13.5	3.1	2.6	6.1	282.0	307.3	415 (354, 502)	0.47 (0.23, 0.71)
41. Lexington-Fayette, KY	9.3	0.3	0.4	0.4	6.8	17.2	27 (22, 33)	0.37 (0.21, 0.54)
42. Sioux Falls, SD	2.2	5.5	0.2	0.3	6.8	15	32 (28, 39)	0.33 (0.22, 0.48)
43. Fairfield, CA	10.0	0.7	0.2	0.3	3.8	15	23 (21, 24)	0.24 (0.11, 0.38)
44. St. Louis, MO--IL	18.3	5.6	3.2	3.0	13.7	43.8	28 (21, 37)	0.51 (0.24, 0.73)
45. McKinney, TX	5.6	0.3	0.3	0.6	2.1	8.9	21 (16, 32)	0.42 (0.21, 0.65)
46. Chattanooga, TN--GA	13.8	0.7	0.6	0.6	6.1	21.8	22 (13, 31)	0.33 (0.21, 0.45)
47. Washington, DC--VA--MD	12.4	6.6	6.8	7.4	16.3	49.5	29 (15, 39)	0.24 (0.06, 0.39)
48. Lansing, MI	11.0	0.3	0.5	0.9	6.2	18.9	22 (12, 28)	0.33 (0.13, 0.58)
49. Mauldin--Simpsonville, SC	4.2	1.0	0.2	0.1	0.7	6.2	17 (12, 28)	0.30 (0.17, 0.45)
50. Greensboro, NC	12.7	0.4	0.5	0.3	5.5	19.4	19 (15, 23)	0.44 (0.30, 0.58)
51. Appleton, WI	9.0	0.3	0.3	0.4	11.7	21.7	33 (25, 44)	0.22 (0.08, 0.43)
52. York, PA	5.2	1.1	0.3	0.9	6.2	13.7	25 (20, 31)	0.21 (0.09, 0.37)
53. Concord, NC	6.9	0.2	0.3	0.3	5.8	13.5	21 (18, 25)	0.30 (0.18, 0.42)
54. Kingsport, TN--VA	17.2	0.5	0.2	0.2	11.1	29.2	22 (19, 28)	0.52 (0.31, 0.72)
55. Modesto, CA	3.1	0.6	0.5	0.6	47.5	52.3	103 (89, 127)	0.38 (0.21, 0.58)
56. Nashville-Davidson, TN	4.0	6.1	1.4	1.5	17.3	30.3	32 (27, 40)	0.22 (0.11, 0.32)
57. Fort Collins, CO	7.6	0.2	0.4	1.0	21.3	30.5	35 (33, 39)	0.20 (0.11, 0.30)
58. Mission Viejo--Lake Forest--San Clemente, CA	12.5	3.2	0.9	0.6	2.1	19.3	17 (13, 20)	0.52 (0.39, 0.65)

Table S2 (page 3 of 4): Methane emissions from urban areas in the contiguous U.S. (CONUS) for 2019.

Urban area[1]	Spatially allocated GHGI emissions (Gg a^{-1})[2]						Posterior emissions	
	Landfills	Wastewater	Post-meter gas	Gas distribution	Other anthropogenic	Total	Total (Gg a^{-1})[3]	Sensitivity[4]
59. Tallahassee, FL	3.5	0.0	0.4	0.2	2.1	6.2	16 (13, 18)	0.23 (0.05, 0.44)
60. Laredo, TX	7.9	1.1	0.4	0.6	12.6	22.6	25 (17, 30)	0.36 (0.18, 0.58)
61. Wichita, KS	6.2	2.4	0.7	1.4	5.2	15.9	16 (14, 18)	0.29 (0.17, 0.42)
62. Canton, OH	8.8	0.4	0.4	0.8	15.3	25.7	25 (15, 33)	0.36 (0.15, 0.61)
63. Fort Smith, AR--OK	4.0	0.4	0.2	0.5	14.9	20	38 (32, 41)	0.50 (0.27, 0.75)
64. Jacksonville, NC	4.6	0.0	0.2	0.1	5.2	10.1	15 (13, 17)	0.24 (0.06, 0.53)
65. Lincoln, NE	7.3	0.2	0.4	0.7	6.5	15.1	15 (12, 17)	0.20 (0.10, 0.33)
66. Bakersfield, CA	3.6	0.9	0.8	0.7	30.9	36.9	78 (71, 90)	0.61 (0.37, 0.80)
67. Tucson, AZ	6.6	0.3	1.3	0.6	6.7	15.5	17 (14, 22)	0.24 (0.16, 0.34)
68. Amarillo, TX	3.7	1.1	0.3	0.7	16.4	22.2	40 (31, 51)	0.57 (0.39, 0.74)
69. Antioch, CA	4.9	0.4	0.4	0.5	9.1	15.3	13 (-1, 22)	0.24 (0.13, 0.37)
70. Santa Clarita, CA	7.5	0.8	0.4	0.6	3.9	13.2	10 (7, 12)	0.27 (0.19, 0.36)
71. El Centro--Calexico, CA	3.2	0.6	0.2	0.2	8.9	13.1	22 (19, 27)	0.29 (0.17, 0.44)
72. College Station--Bryan, TX	3.3	0.1	0.3	0.5	15.8	20	29 (26, 31)	0.22 (0.12, 0.34)
73. Waco, TX	4.4	0.1	0.3	0.6	3.9	9.3	11 (8, 14)	0.20 (0.10, 0.32)
74. McAllen, TX	7.3	1.0	1.1	2.2	21.0	32.6	38 (32, 46)	0.33 (0.19, 0.49)
75. Yuba City, CA	3.4	0.1	0.2	0.2	19.1	23	24 (20, 26)	0.41 (0.25, 0.58)
76. Denton--Lewisville, TX	2.2	0.2	0.5	1.2	17.1	21.2	34 (32, 37)	0.36 (0.21, 0.51)
77. Greeley, CO	2.4	0.0	0.2	0.5	31.4	34.5	57 (44, 76)	0.58 (0.36, 0.79)
78. Redding, CA	3.4	0.6	0.2	0.2	1.3	5.7	7 (6, 8)	0.53 (0.36, 0.66)
79. Norman, OK	2.1	0.1	0.2	0.4	1.9	4.7	8 (8, 9)	0.23 (0.12, 0.37)
80. Victorville--Hesperia, CA	3.4	0.4	0.5	0.4	5.9	10.6	10 (8, 13)	0.22 (0.13, 0.31)
81. Visalia, CA	2.6	0.5	0.3	0.4	76.5	80.3	72 (63, 82)	0.22 (0.13, 0.33)
82. Gainesville, GA	3.7	0.0	0.2	0.2	4.4	8.5	8 (3, 11)	0.21 (0.10, 0.33)
83. Murrieta--Temecula--Menifee, CA	1.5	1.0	0.7	0.6	4.4	8.2	11 (10, 12)	0.21 (0.14, 0.29)
84. Monroe, LA	3.8	0.2	0.2	0.3	10.3	14.8	8 (-4, 14)	0.22 (0.10, 0.35)
85. Merced, CA	1.0	0.3	0.2	0.2	71.4	73.1	146 (130, 171)	0.44 (0.27, 0.63)
86. Abilene, TX	2.4	0.7	0.2	0.3	4.6	8.2	9 (8, 10)	0.20 (0.10, 0.34)
87. Charleston, WV	5.2	0.4	0.2	1.8	116.8	124.4	24 (-3, 52)	0.52 (0.29, 0.76)

Table S2 (page 4 of 4): Methane emissions from urban areas in the contiguous U.S. (CONUS) for 2019.

Urban area[1]	Spatially allocated GHGI emissions (Gg a^{-1})[2]						Posterior emissions	
	Landfills	Wastewater	Post-meter gas	Gas distribution	Other anthropogenic	Total	Total (Gg a^{-1})[3]	Sensitivity[4]
88. Odessa, TX	3.7	0.3	0.2	0.4	81.9	86.5	175 (139, 217)	0.46 (0.36, 0.58)
89. Avondale--Goodyear, AZ	1.6	0.3	0.3	0.1	3.2	5.5	5 (5, 6)	0.42 (0.27, 0.57)
90. Midland, TX	2.4	0.2	0.2	0.5	83.5	86.8	41 (-22, 90)	0.71 (0.52, 0.86)
91. Las Cruces, NM	0.7	0.3	0.2	0.2	6.3	7.7	6 (4, 8)	0.21 (0.13, 0.30)
92. Pueblo, CO	4.1	0.1	0.2	0.3	1.1	5.8	1 (-3, 3)	0.26 (0.16, 0.39)
93. Simi Valley, CA	2.1	0.1	0.2	0.1	0.3	2.8	-1 (-4, 0)	0.27 (0.19, 0.37)
94. Clarksville, TN--KY	7.0	0.6	0.2	0.2	3.7	11.7	0 (-5, 5)	0.28 (0.16, 0.43)
95. Kansas City, MO--KS	34.6	3.2	2.3	3.3	17.3	60.7	3 (-19, 21)	0.45 (0.22, 0.71)

[1]Urban areas with populations greater than 1 million that are optimized by the inversion (mean urban averaging kernel sensitivity greater than 0.2), ordered by posterior emissions from landfills, wastewater, and gas distribution. Urban area extents are given by the U.S. Census Topographically Integrated Geographic Encoding and Referencing system (TIGER)/Line Urban Areas.

[2]The anthropogenic emissions for urban source sectors for each city in gigagrams per year (Gg a^{-1}) from the 2023 EPA GHGI for 2019 allocated using the Gridded EPA inventory (Maasakkers et al., 2016) with post-meter emissions distributed by population. Other emissions include contributions from upstream oil and gas, coal, livestock, and other sources.

[3]Optimized emissions from inversion of TROPOMI observations in gigagrams per year. Values in parentheses represent the range from an eight-member inversion ensemble.

[4]The sensitivity of an urban area to the satellite-model observing system as given by the diagonal elements of the urban averaging kernel matrix calculated as described in Section 2.8. Values close to 1 indicate that the posterior emissions are fully sensitive to the observing system, while values close to 0 rely almost entirely on the prior estimate. Values in parentheses give the ensemble range.

Table S3 (page 1 of 2): Methane emissions from landfills in the contiguous United States (CONUS) for 2019.

Facility[1]	Location	Emissions (Gg a^{-1})		Gas capture efficiency	
		GHGRP[2]	Posterior[3]	GHGRP[4]	Posterior[5]
1. National Serv-All Landfill	Fort Wayne, Indiana	3.4	44 (34 - 59)	0.86	0.32 (0.26 - 0.37)
2. South Shelby Landfill	Memphis, Tennessee	4.1	41 (30 - 56)	0.86	0.39 (0.31 - 0.46)
3. South Side Landfill Inc.	Indianapolis, Indiana	4.7	39 (32 - 52)	0.8	0.33 (0.27 - 0.38)
4. Rumpke Sanitary Landfill	Cincinnati, Ohio	10.1	39 (33 - 43)	0.84	0.58 (0.55 - 0.61)
5. Quad Cities Landfill Phase IV	Milan, Illinois	3.7	35 (28 - 47)	N/A	N/A
6. City of Dothan Sanitary Landfill	Dothan, Alabama	5.8	35 (28 - 43)	N/A	N/A
7. Rochelle Municipal Landfill	Rochelle, Illinois	2.7	32 (25 - 39)	0.76	0.22 (0.18 - 0.26)
8. Seminole Road MSW Landfill	Ellenwood, Georgia	12.3	30 (25 - 36)	0.18	0.08 (0.07 - 0.1)
9. Sampson County Disposal, LLC	Roseboro, North Carolina	29.2	25 (23 - 29)	0.37	0.41 (0.38 - 0.44)
10. West Miramar Sanitary Landfill	San Diego, California	6.2	24 (22 - 25)	0.78	0.47 (0.46 - 0.49)
11. Seneca Meadows SWMF	Waterloo, New York	8.3	24 (14 - 36)	0.88	0.73 (0.63 - 0.81)
12. Kiefer Landfill	Sloughhouse, California	6.5	24 (19 - 31)	0.81	0.54 (0.46 - 0.58)
13. Charlotte Motor Speedway Landfill V	Concord, North Carolina	6.9	23 (18 - 30)	0.75	0.48 (0.41 - 0.54)
14. Puente Hills Landfill and Energy Recovery	Whittier, California	2.7	22 (19 - 27)	0.94	0.67 (0.61 - 0.69)
15. Atascocita Recycling and Disposal Facility	Humble, Texas	11.9	21 (16 - 26)	0.59	0.45 (0.4 - 0.52)
16. Frank R. Bowerman Landfill	Irvine, California	11.8	21 (16 - 32)	0.77	0.66 (0.56 - 0.71)
17. Kimble Sanitary Landfill	Dover, Ohio	2.8	19 (17 - 24)	N/A	N/A
18. 121 Regional Disposal Facility	Melissa, Texas	20.7	19 (14 - 29)	0.49	0.52 (0.4 - 0.58)
19. New Georgia Landfill	Birmingham, Alabama	5.5	19 (17 - 21)	N/A	N/A
20. Sussex County Landfill	Waverly, Virginia	7.3	17 (12 - 25)	N/A	N/A
21. Altamont Landfill & Resource Recovery Facility	Livermore, California	7.3	17 (13 - 23)	0.74	0.56 (0.48 - 0.63)
22. Enoree Landfill	Greer, South Carolina	3.4	17 (11 - 28)	0.52	0.19 (0.11 - 0.24)
23. Brent Run Landfill	Montrose, Michigan	18.2	17 (14 - 21)	0.35	0.37 (0.32 - 0.42)
24. Livingston Landfill	Pontiac, Illinois	4.9	17 (14 - 20)	0.85	0.62 (0.58 - 0.66)
25. Big River Landfill	Leland, Missouri	6	16 (13 - 21)	N/A	N/A
26. Modern Landfill	York, Pennsylvania	3.4	15 (11 - 22)	N/A	N/A
27. Newby Island Landfill	Milpitas, California	5.5	15 (13 - 21)	N/A	N/A
28. Landfill of North Iowa	Clear Lake, Iowa	2.8	14 (11 - 18)	N/A	N/A
29. Beech Hollow Sanitary Landfill	Wellston, Ohio	14.5	13 (9 - 20)	N/A	N/A
30. Rumpke of Kentucky Inc.	Jeffersonville, Kentucky	9.2	12 (9 - 15)	N/A	N/A
31. Jefferson County Landfill No. 1	Gardendale, Alabama	8.8	11 (10 - 14)	N/A	N/A
32. Keller Canyon Landfill	Pittsburg, California	5.6	10 (8 - 13)	0.55	0.4 (0.35 - 0.47)
33. Big Run Landfill	Ashland, Kentucky	20.9	10 (9 - 12)	N/A	N/A
34. Rockingham County Landfill	Madison, North Carolina	3.4	10 (6 - 13)	0.3	0.13 (0.1 - 0.19)
35. Granger Grand River Avenue Landfill	Grand Ledge, Michigan	4.3	10 (2 - 14)	0.57	0.4 (0.3 - 0.71)
36. Leon County Landfill	Tallahassee, Florida	3.2	9 (8 - 11)	N/A	N/A
37. City of Laredo Landfill	Laredo, Texas	6.6	9 (4 - 12)	N/A	N/A

Table S3 (page 2 of 2): Methane emissions from landfills in the contiguous United States (CONUS) for 2019.

Facility[1]	Location	Emissions (Gg a^{-1})		Gas capture efficiency	
		GHGRP[2]	Posterior[3]	GHGRP[4]	Posterior[5]
38. Onslow County Landfill	Jacksonville, North Carolina	3.1	9 (8 - 10)	0.53	0.28 (0.25 - 0.3)
39. Waste Management Skyline Landfill	Ferris, Texas	13.8	9 (6 - 12)	0.4	0.5 (0.43 - 0.6)
40. Matlock Bend Landfill	Loudon, Tennessee	6.2	8 (6 - 14)	N/A	N/A
41. Waste Management of OK	Tulsa, Oklahoma	6.2	8 (6 - 13)	0.29	0.24 (0.17 - 0.29)
42. City of Chattanooga Summit Landfill	Ooltewah, Tennessee	3.1	8 (2 - 14)	N/A	N/A
43. La Salle/Grant Parish Sanitary Landfill	Jena, Louisiana	5.3	7 (5 - 8)	N/A	N/A
44. Badlands Sanitary Landfill	Moreno Valley, California	3.2	7 (5 - 8)	N/A	N/A
45. Bluff Road Landfill	Lincoln, Nebraska	2.9	7 (5 - 10)	0.69	0.5 (0.4 - 0.57)
46. Bradley County Landfill	Mcdonald, Tennessee	10.2	7 (4 - 9)	N/A	N/A
47. Mccombs Landfill	El Paso, Texas	11.5	6 (5 - 8)	N/A	N/A
48. Toro Energy of Ohio - America's Landfill Gas	Waynesburg, Ohio	2.7	6 (1 - 10)	0.78	0.63 (0.47 - 0.9)
49. Carbon Limestone Landfill	Lowellville, Ohio	3.6	6 (3 - 8)	0.89	0.83 (0.79 - 0.89)
50. City Of Glendale - Landfill	Glendale, Arizona	5	5 (5 - 6)	0.5	0.49 (0.44 - 0.52)
51. Lone Cactus Landfill	Phoenix, Arizona	2.7	5 (4 - 7)	N/A	N/A
52. Tangerine Landfill	Marana, Arizona	2.6	5 (3 - 7)	N/A	N/A
53. Outagamie County Landfill	Appleton, Wisconsin	2.8	5 (3 - 7)	0.75	0.65 (0.55 - 0.72)
54. Champ Landfill	Maryland Heights, Missouri	9.8	4 (1 - 8)	0.73	0.86 (0.77 - 0.97)
55. Rhea County Landfill	Dayton, Tennessee	8.3	4 (4 - 5)	N/A	N/A
56. Noble Road Landfill	Shiloh, Ohio	16.2	4 (1 - 7)	N/A	N/A
57. Copper Mountain Landfill	Wellton, Arizona	4.7	4 (4 - 4)	N/A	N/A
58. Black Oak Landfill	Hartville, Missouri	3.8	4 (2 - 6)	0.48	0.49 (0.36 - 0.64)
59. Brooks Landfill	Wichita, Kansas	8.3	3 (2 - 4)	N/A	N/A
60. American Environmental Landfill	Sand Springs, Oklahoma	7	3 (2 - 4)	0.45	0.66 (0.59 - 0.78)
61. Prima Deshecha Landfill	San Juan Capistrano, California	5.1	3 (2 - 4)	0.66	0.78 (0.73 - 0.85)
62. Meadow Branch Landfill	Athens, Tennessee	11.2	3 (2 - 3)	0.44	0.77 (0.72 - 0.81)
63. West Central Landfill	Redding, California	2.8	3 (2 - 4)	N/A	N/A
64. Northwestern Landfill	Parkersburg, West Virginia	3.7	2 (0 - 4)	N/A	N/A
65. Northwest Regional Landfill	Surprise, Arizona	4.5	2 (2 - 3)	0.51	0.7 (0.61 - 0.74)
66. Apex Environmental, LLC - Sanitary Landfill	Amsterdam, Ohio	19.5	2 (-9 - 8)	0.27	0.17 (-4.29 - 1.53)
67. Apache Junction Landfill	Apache Junction, Arizona	2.8	2 (1 - 2)	N/A	N/A
68. Hall County Candler Road MSWLF	Gainesville, Georgia	2.9	2 (-2 - 4)	N/A	N/A
69. Laurel Ridge Landfill	Lily, Kentucky	10.1	1 (0 - 4)	0.3	0.77 (0.52 - 0.96)
70. Cactus Landfill	Eloy, Arizona	3.2	1 (-1 - 1)	N/A	N/A

[1]The 70 landfills that report methane emissions of 2.5 Gg a^{-1} to the EPA GHGRP and that are located in a grid cell where TROPOMI provides a constraint (averaging kernel sensitivity > 0.2) and where a single landfill explains more than 50% of the prior emissions estimate. Facilities are ranked by the posterior emissions estimate from largest to smallest.
[2]Emissions reported by individual landfills to the EPA GHGRP for 2019 in gigagrams per year.
[3]Posterior emissions from inversion of TROPOMI observations in gigagrams per year. Posterior emissions are allocated to individual facilities as described in Sections 2.8 and 3.2. Values in parentheses represent the range from the eight-member inversion ensemble.
[4]For facilities that capture landfill gas, the recovery efficiency as calculated from emissions and avoided emissions reported by individual landfills to the EPA LMOP. Facilities that do not capture landfill gas are listed as N/A.
[5]The posterior recovery efficiency as calculated from posterior emissions and the avoided emissions reported by individual landfills to the EPA LMOP.