

Supplementary Information for:

Automatic Methane Plume Masking Based on Wavelet
Transform Image Processing: Application to MethaneAIR and
MethaneSAT data

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1 Supplemental Methods

1.1 Sensitivity analysis

For the parameters that need to be empirically determined, we provide a detailed sensitivity analysis to show how different values affect detection results. For MethaneAIR, these parameters include: the scaling factor to determine the pre-processing pixel value threshold (Table S1), the scaling factor to determine the plume masking pixel value threshold (Table S2), the plume mask size threshold (Table S3), the plume hotspot size threshold (Table S4), the angle buffer in wind direction filtering (Table S5), and the fiber length ratio in shape filtering (Table S6). For MethaneSAT, we include the same six parameters above, plus the local background width to determine the pre-processing pixel value threshold (Table S8), and the local background width to determine the plume masking pixel value threshold (Table S10).

Here the scaling factors are used for determining thresholds for denoising or masking, where the threshold used is the mean XCH_4 value of the scene plus the scaling factor times the standard deviation of XCH_4 for the scene.

For each parameter, we independently choose three example scenes that have numerous plumes and represent varying surface features and local wind characteristics for MethaneAIR and MethaneSAT, respectively: Scene 1 represents the Permian basin (high albedo) with high wind speed, Scene 2 repre-

sents the Appalachian basin (low albedo), and Scene 3 represents the Permian basin with low wind speed.

2 Supplemental Figures

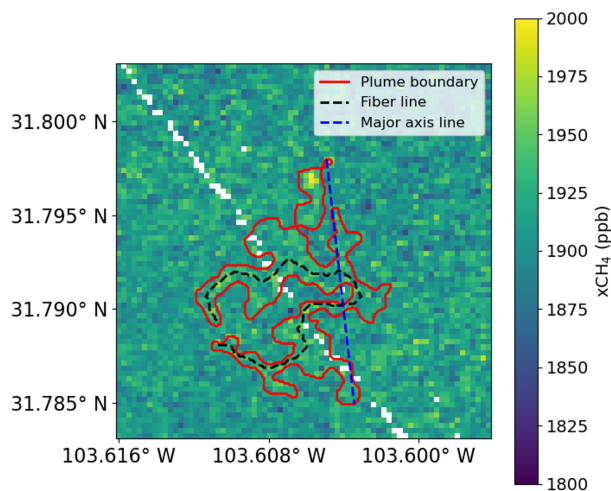


Figure S1: A MethaneAIR false plume example with the “spider” shape plume mask. Such a mask has its fiber line (black) much longer than its major axis line (blue)

3 Supplemental Tables

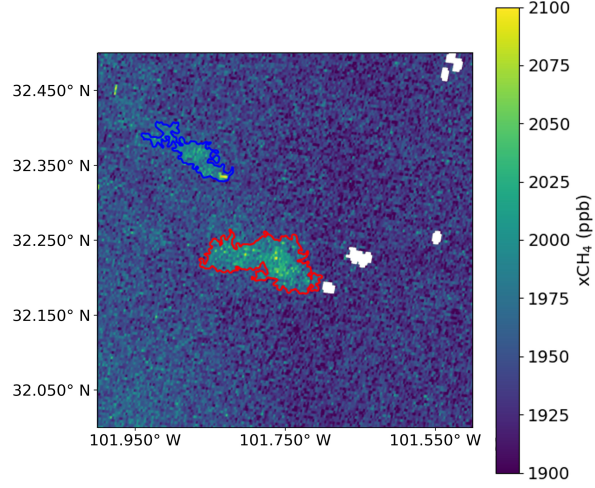


Figure S2: A MethaneSAT false plume example with no clear hotspots (red). This could be a diffuse enhancement from a source that stopped emitting, thus the plume was observed downwind of the source. In comparison, clear hotspot can be easily found in a true plume (blue).

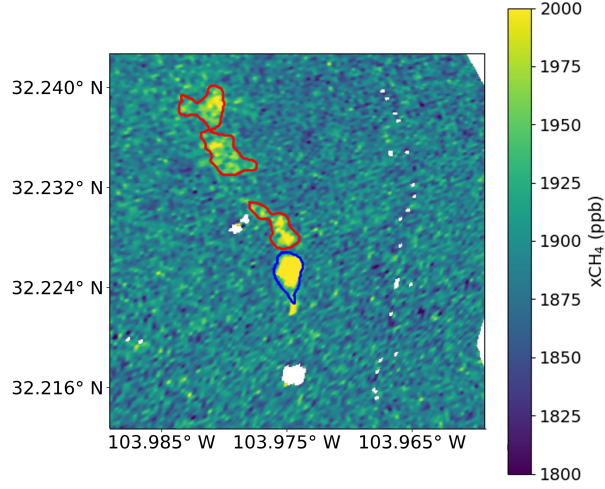


Figure S3: A MethaneAIR example of a plume dissected into multiple detached clumps by eddies. In this case, the plume mask closest to the source (blue) is considered true and the others downwind (red) are considered false.

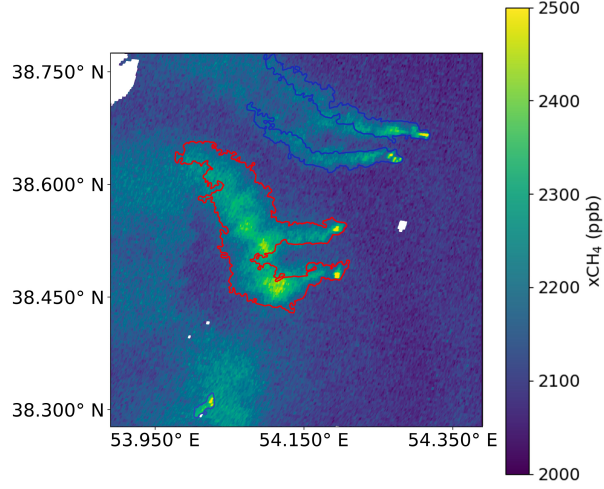


Figure S4: A MethaneSAT subspace with two plumes merging in the downwind direction. In this case, the plume mask that covers the two merged plumes (red) is considered false, and the others (blue) are considered true.

Pre-processing scaling factor - MethaneAIR						
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
1.0	54	47	41	20	15	5
1.5	53	33	40	6	13	1
2.0	56	21	37	4	13	1
2.5	49	18	37	3	7	1

Table S1: Sensitivity analysis for the pre-processing scaling factor in three MethaneAIR flights with varying surface features and wind speeds. 2.0 is the final choice.

	Plume masking scaling factor - MethaneAIR					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
1.0	53	50	40	10	11	10
1.5	56	21	37	4	13	1
2.0	50	19	36	2	12	0
2.5	43	9	33	2	12	0

Table S2: Sensitivity analysis for the plume masking scaling factor in three MethaneAIR flights with varying surface features and wind speeds. 1.5 is the final choice.

	Plume mask size - MethaneAIR					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
50	58	32	41	17	15	10
100	56	21	37	4	13	1
150	54	20	37	4	13	1
200	54	17	37	4	13	1

Table S3: Sensitivity analysis for the plume mask size in three MethaneAIR flights with varying surface features and wind speeds. 100 is the final choice.

	Plume hotspot size - MethaneAIR					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
50	56	35	37	20	13	8
10	56	21	37	4	13	1
15	51	18	37	4	13	1
20	49	13	34	4	13	1

Table S4: Sensitivity analysis for the plume hotspot size in three MethaneAIR flights with varying surface features and wind speeds. 10 is the final choice.

	Wind direction filter angle buffer - MethaneAIR					
	Scene 1		Scene 2		Scene 3	
Values (°)	# True	# False	# True	# False	# True	# False
45	51	18	36	4	13	0
50	55	21	37	4	13	0
55	56	21	37	4	13	1
60	56	29	39	9	13	2

Table S5: Sensitivity analysis for the wind direction filter angle buffer in three MethaneAIR flights with varying surface features and wind speeds. 55° is the final choice.

	Fiber length ratio - MethaneAIR					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
1.00	41	17	26	4	11	1
1.25	56	21	37	4	13	1
1.50	56	26	37	8	13	4
1.75	46	28	37	11	13	4

Table S6: Sensitivity analysis for the fiber length ratio in three MethaneAIR flights with varying surface features and wind speeds. 1.25 is the final choice.

	Pre-processing scaling factor - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
1.25	8	7	12	16	1	4
1.50	8	3	12	10	1	2
1.75	7	2	12	8	1	0
2.00	2	0	7	3	1	0

Table S7: Sensitivity analysis for the pre-processing scaling factor in three MethaneSAT flights with varying surface features and wind speeds. 1.75 is the final choice.

	Pre-processing local background width - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values (m)	# True	# False	# True	# False	# True	# False
2250	4	2	12	8	1	0
4500	7	2	12	8	1	0
6750	7	3	10	12	1	0
9000	5	1	11	7	1	0

Table S8: Sensitivity analysis for the pre-processing local background width in three MethaneSAT flights with varying surface features and wind speeds. 4500m is the final choice.

	Plume masking scaling factor - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
1.25	8	6	12	12	1	5
1.50	7	3	12	11	1	0
1.75	7	2	12	8	1	0
2.00	4	0	7	3	1	0

Table S9: Sensitivity analysis for the plume masking scaling factor in three MethaneSAT flights with varying surface features and wind speeds. 1.75 is the final choice.

	Plume masking local background width - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values (m)	# True	# False	# True	# False	# True	# False
2250	6	2	12	8	1	0
4500	7	2	12	8	1	0
6750	7	2	12	8	1	0
9000	5	0	10	5	1	0

Table S10: Sensitivity analysis for the plume masking local background width in three MethaneSAT flights with varying surface features and wind speeds. 4500m is the final choice.

	Plume mask size - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
250	8	15	12	14	1	3
500	7	2	12	8	1	0
750	5	2	11	6	1	0
1000	3	2	11	4	1	0

Table S11: Sensitivity analysis for the plume mask size in three MethaneSAT flights with varying surface features and wind speeds. 500 is the final choice.

	Plume hotspot size - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
10	7	2	12	11	1	0
20	7	2	12	8	1	0
30	7	2	11	8	1	0
40	7	2	11	6	1	0

Table S12: Sensitivity analysis for the plume hotspot size in three MethaneSAT flights with varying surface features and wind speeds. 20 is the final choice.

	Wind direction filter angle buffer - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values (°)	# True	# False	# True	# False	# True	# False
45	7	2	12	8	1	0
50	7	2	12	8	1	0
55	7	2	12	8	1	0
60	7	2	12	9	1	0

Table S13: Sensitivity analysis for the wind direction filter angle buffer in three MethaneSAT flights with varying surface features and wind speeds. 55° is the final choice.

	Fiber length ratio - MethaneSAT					
	Scene 1		Scene 2		Scene 3	
Values	# True	# False	# True	# False	# True	# False
1.00	4	2	3	4	0	0
1.25	7	2	12	8	1	0
1.50	7	4	12	8	1	0
1.75	7	4	12	10	1	0

Table S14: Sensitivity analysis for the fiber length ratio in three MethaneSAT flights with varying surface features and wind speeds. 1.25 is the final choice.