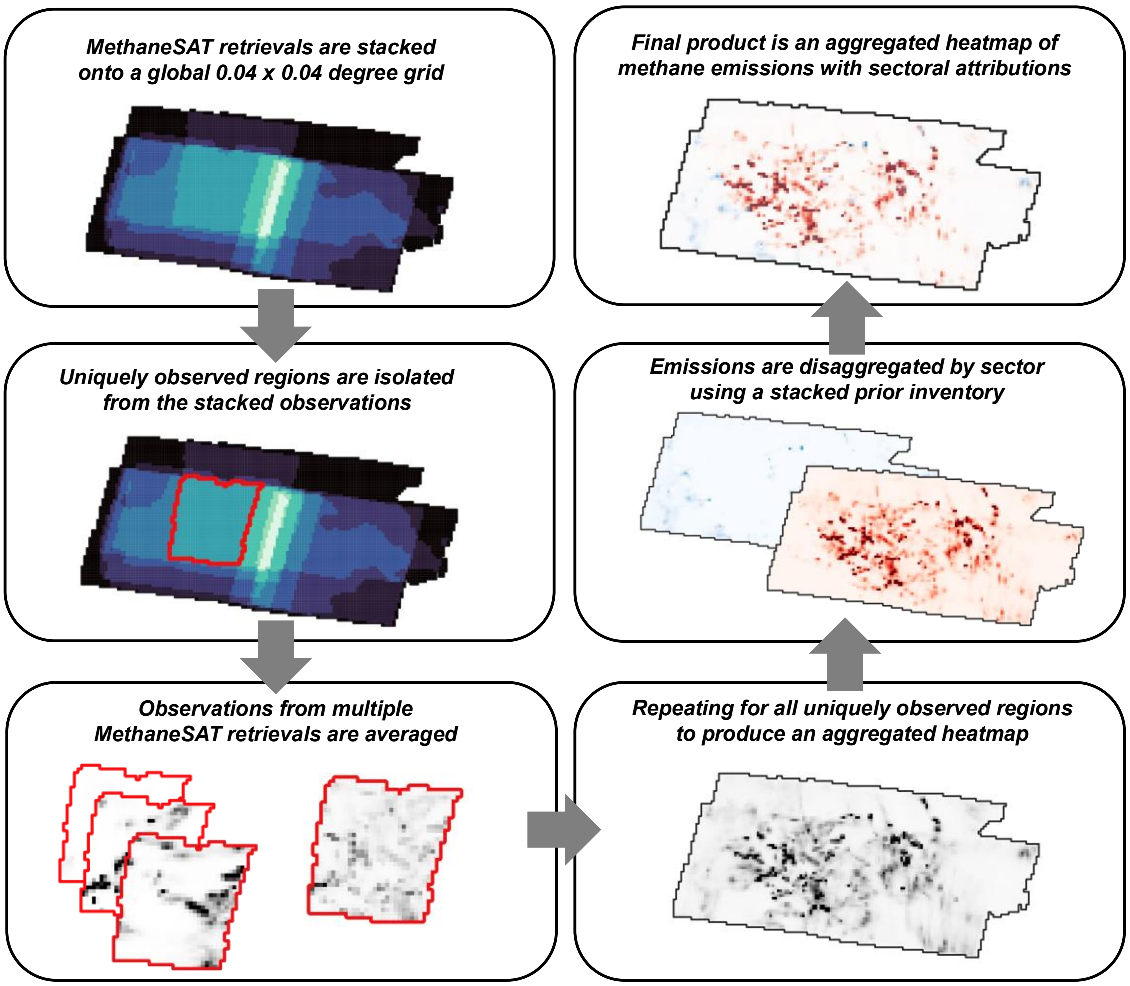

Fig. S1: Diagram illustrating the methodology associated with the aggregation of multiple overlapping MethaneSAT emissions maps into a single regional estimate of methane emissions and the sectoral disaggregation of methane emissions derived from MethaneSAT observations.

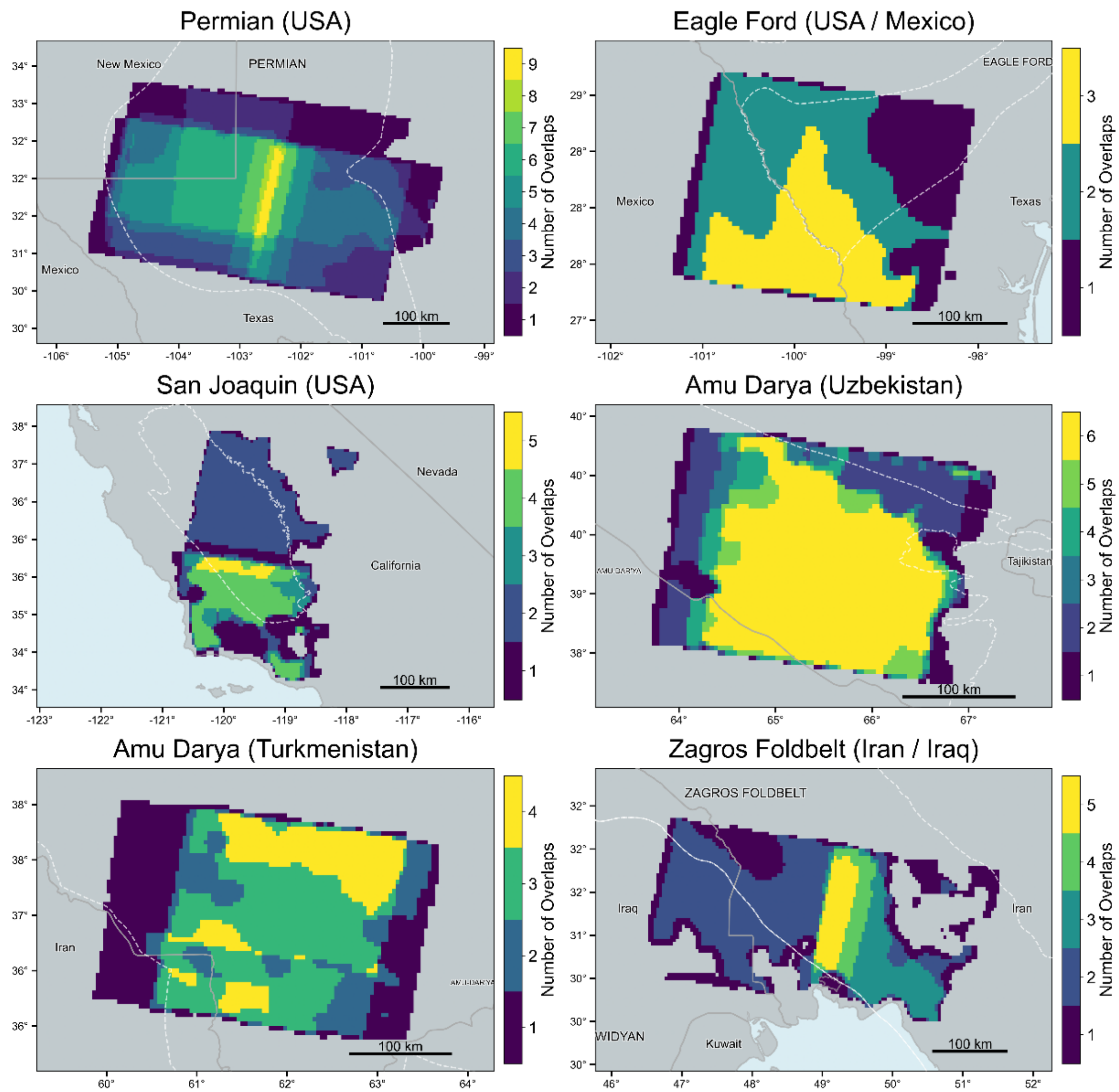

Fig. S2: Maps displaying the number of repeatedly observed areas from the aggregated MethaneSAT retrievals in the Permian (US), Eagle Ford (US, Mexico), San Joaquin (US), two separate Amu Darya regions in Turkmenistan and Uzbekistan, and the Zagros Foldbelt (Iran, Iraq). Aggregagted collections are colored by the number of MethaneSAT observations, which range from a maximum of nine overlapping retrievals in the Permian to three in the Eagle Ford.

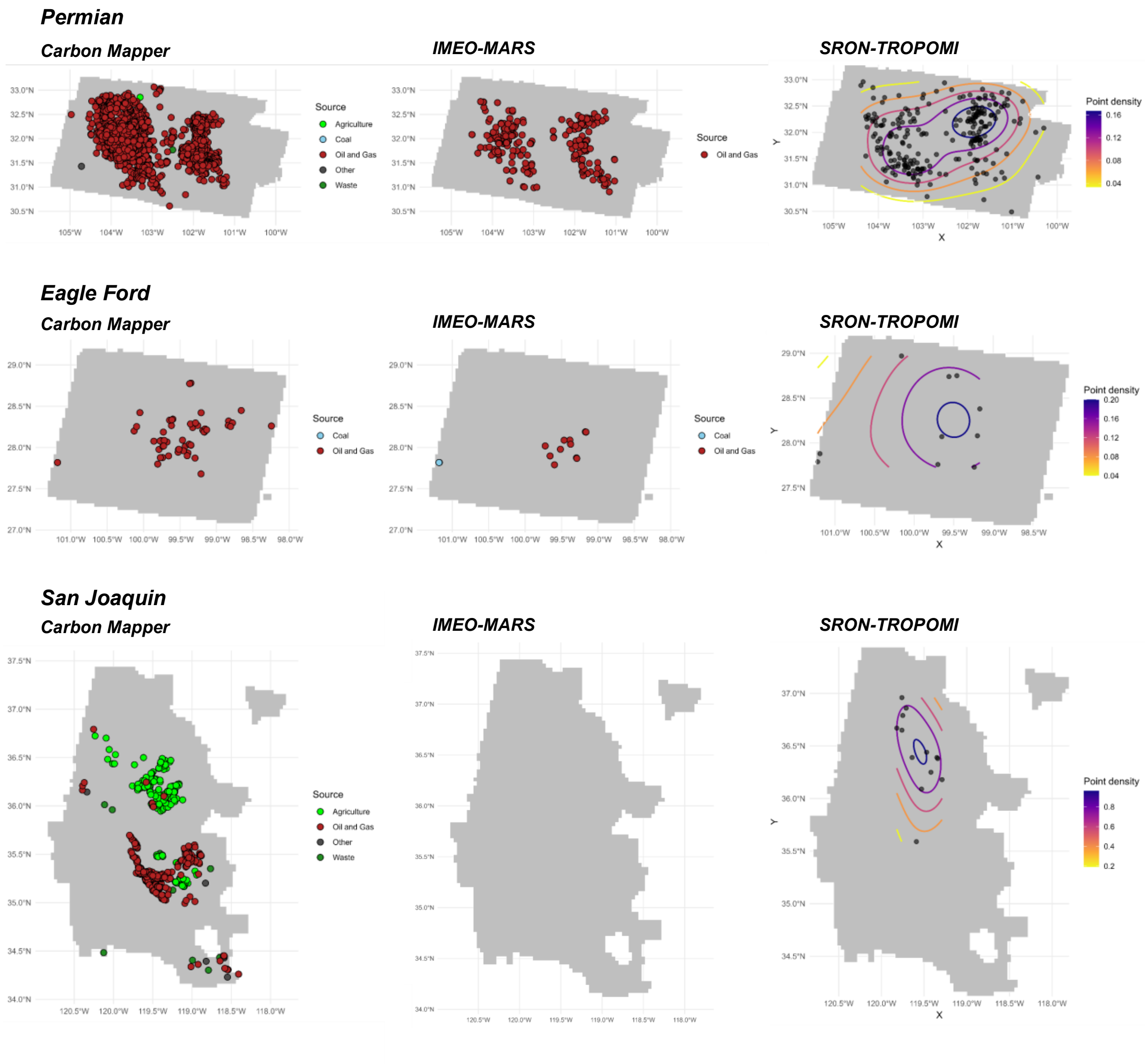

Fig. S3: Maps of distinct point source detections in the US regions from various satellite-based platforms including Carbon Mapper (Tanager, AVIRIS-NG), IMEO-MARS (EMIT, PRISMA), and SRON-TROPOMI (Sentinel 5P). Methane sources detected by Sentinel 5P are effectively methane hotspots, and are subject to a higher degree of spatial uncertainty compared to the other satellite-based instruments. Note that a lack of point source detections in any one region could simply reflect a lack of focused targeting in the instrument(s).

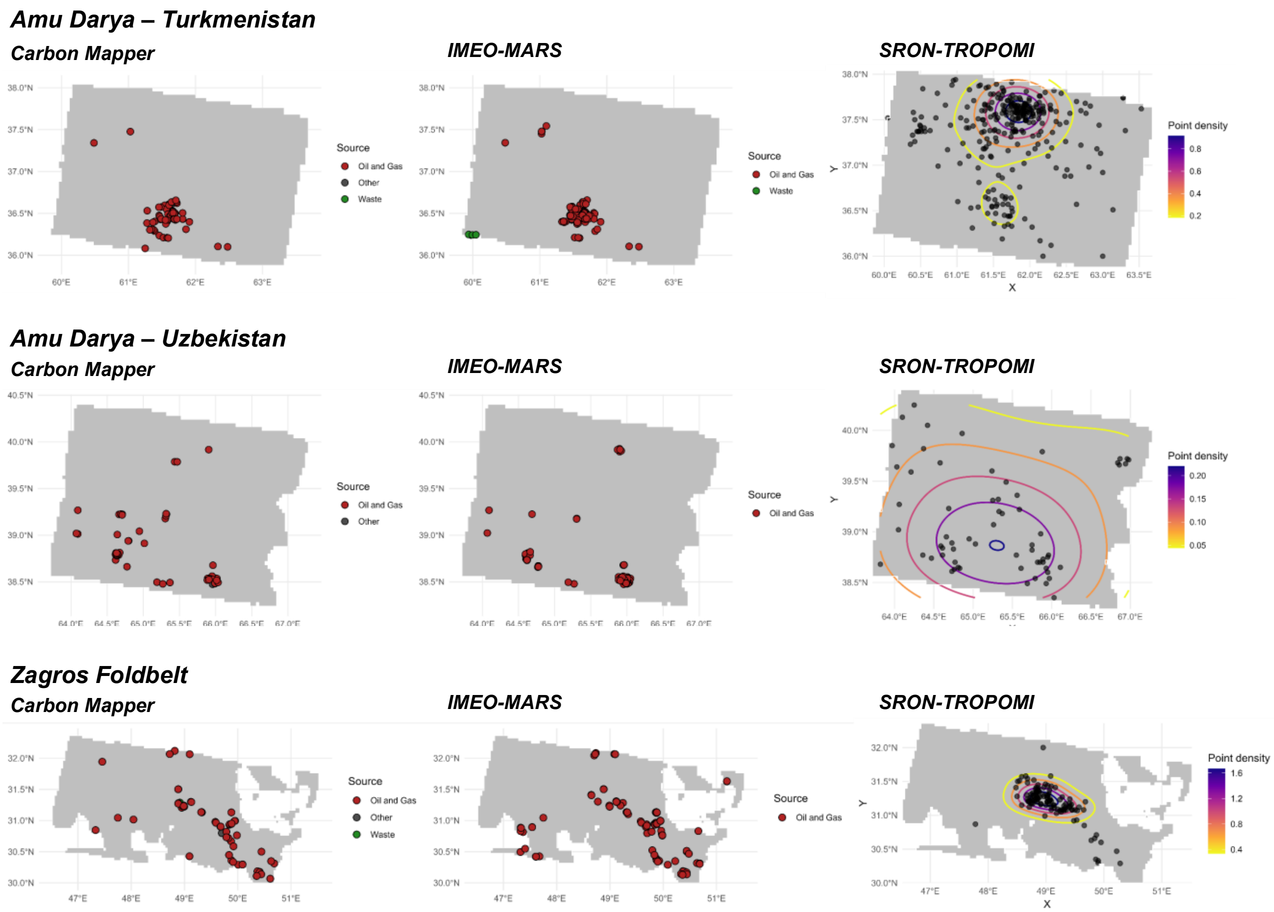

Fig. S4: Maps of distinct point source detections in the regions outside of the US from various satellite-based platforms including Carbon Mapper (Tanager, AVIRIS-NG), IMEO-MARS (EMIT, PRISMA), and SRON-TROPOMI (Sentinel 5P). Methane sources detected by Sentinel 5P are effectively methane hotspots and are subject to a higher degree of spatial uncertainty compared to the other satellite-based instruments. Note that a lack of point source detections in any one region could simply reflect a lack of focused targeting in the instrument(s).

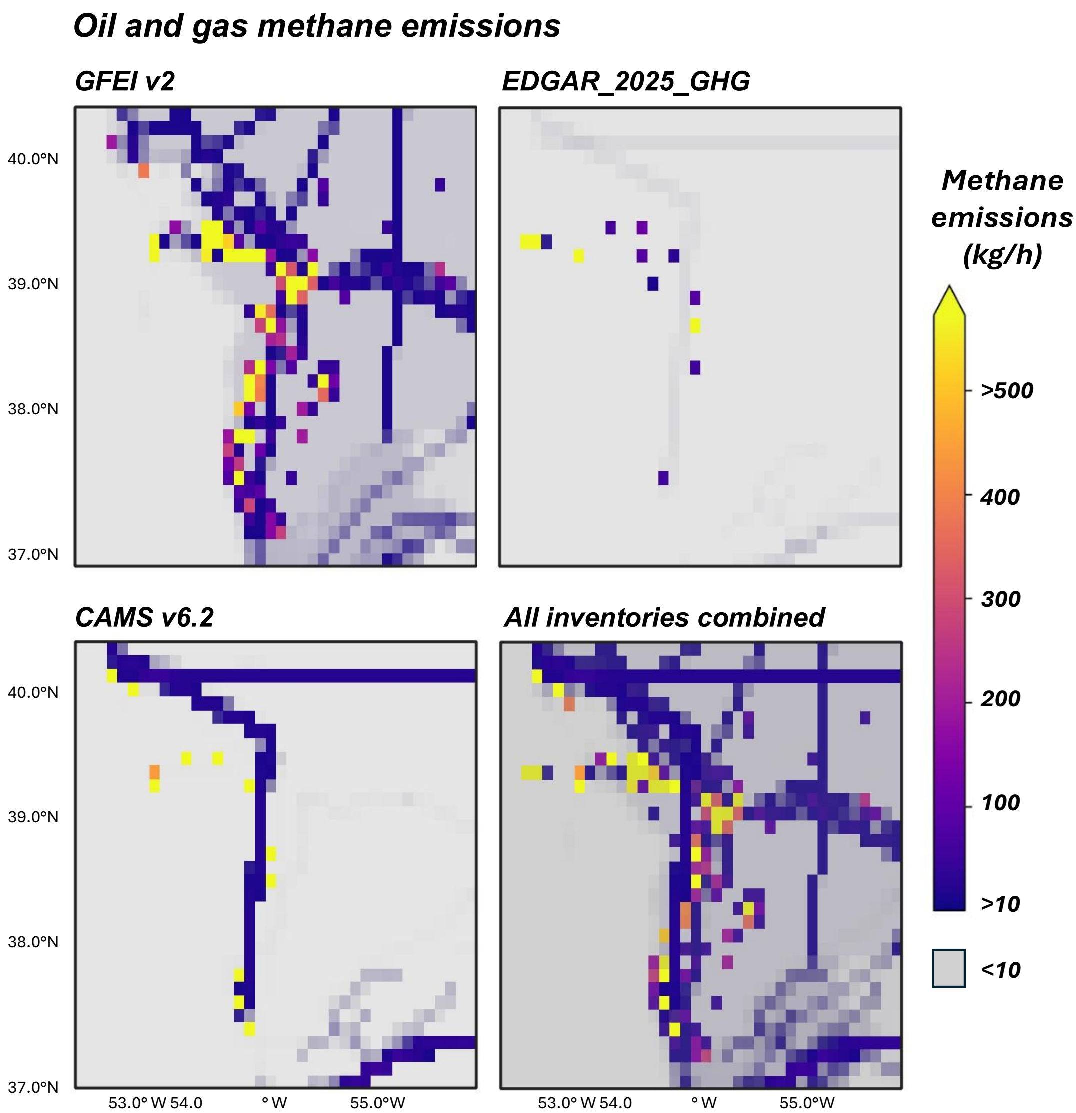

Fig. S5: Example of differences in spatially-explicit bottom-up inventories in the magnitude and spatial allocation of methane emissions from the oil and gas sector. All three inventories are combined to form a compositive inventory – which is presented in the bottom right hand panel. The example region is the South Caspian region of Turkmenistan.

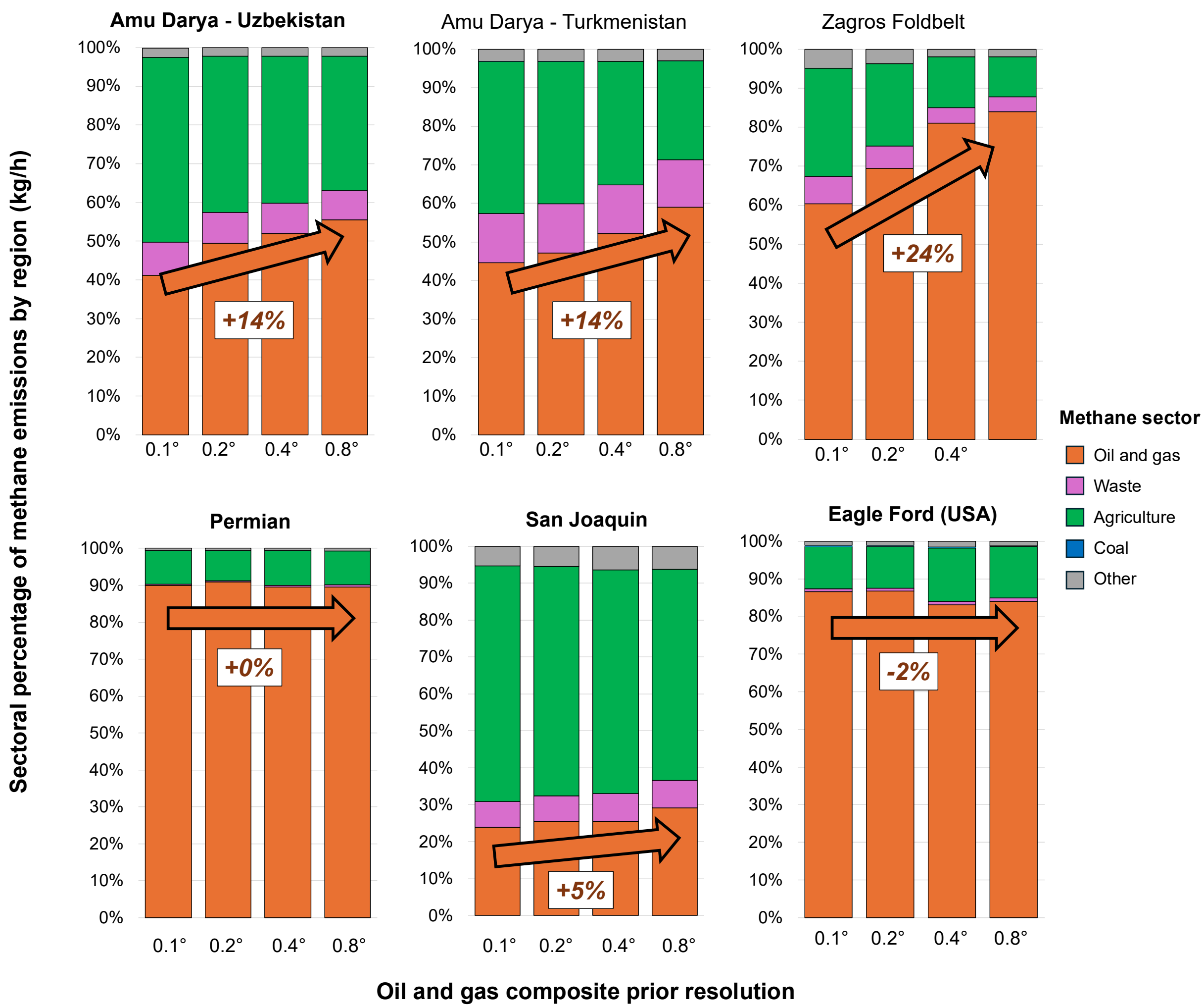

Fig. S6: Impacts of varying the resolution of the oil and gas sectoral emissions from the stacked prior inventory used to disaggregate methane emissions estimates from MethaneSAT. Results of the sensitivity test for all six regions are shown. The percentage difference in the sectoral allocation of emissions under the different scenarios are indicated by the inset text, and represent the difference between the oil and gas composite resolution of 0.1° (i.e., the native resolution of the bottom-up inventories) and 0.8°. IN the main text, we use a resolution of 0.4° for the compositive oil and gas emissions for all regions outside of the us, while maintaining a native resolution of 0.1° for all regions within the US.

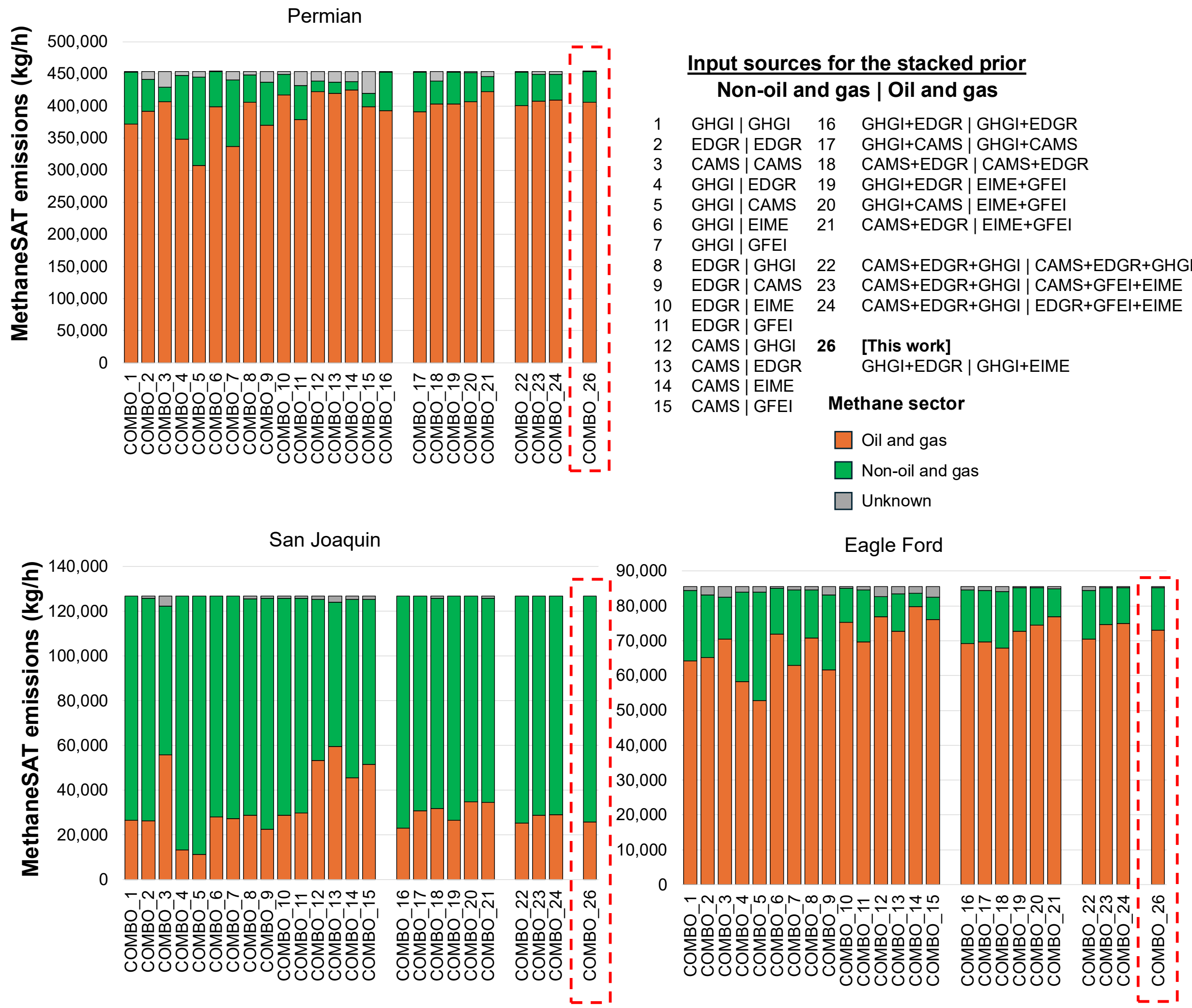

Fig. S7: Impacts of varying the input data used in the stacked prior inventory to disaggregate methane emissions from the MethaneSAT observations for regions in the US. The impacts of the inclusion of Carbon Mapper point sources are also not shown. The specific combination of inventories we present in this work are highlighted in the dashed red bars.

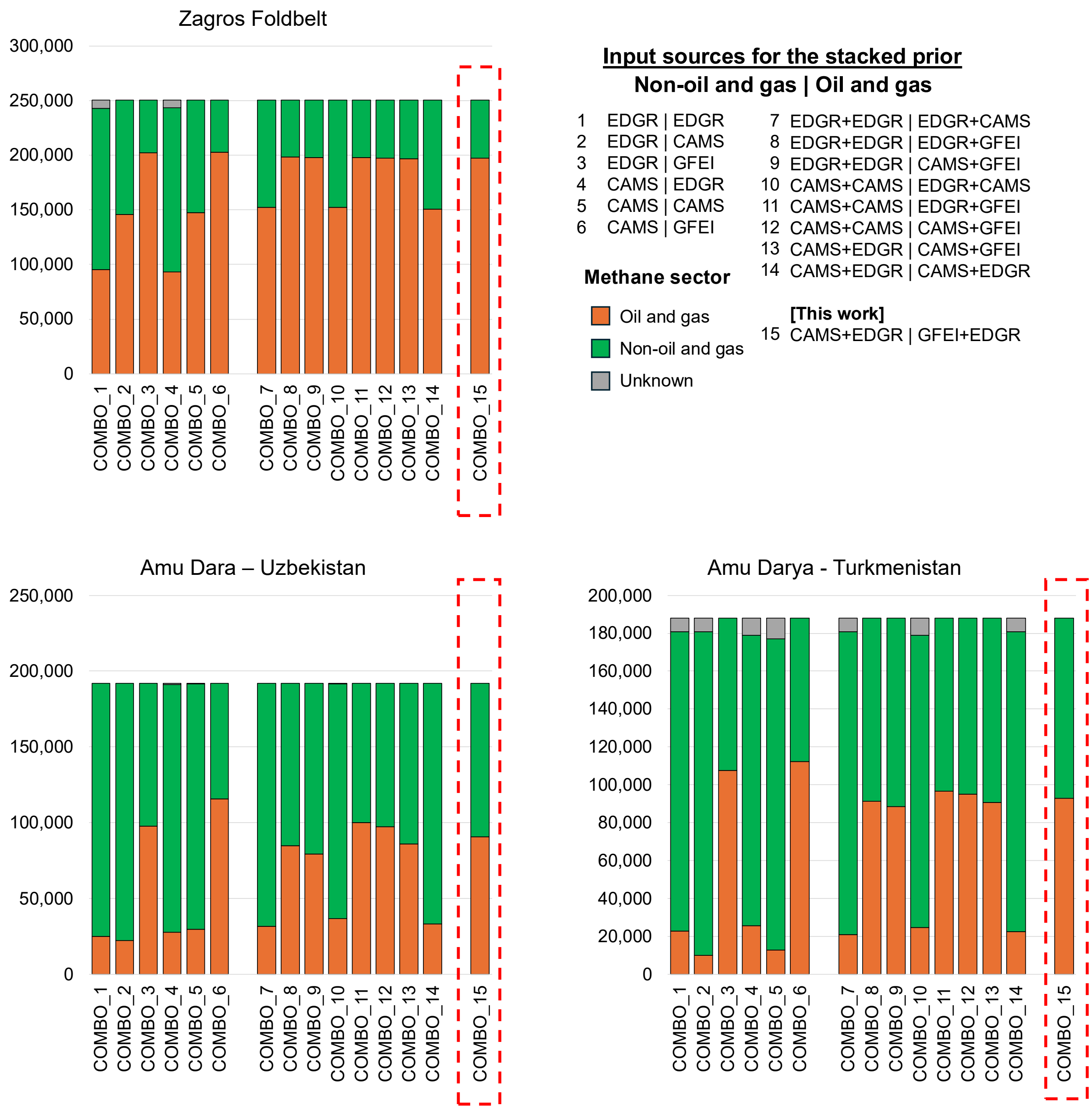

Fig. S8: Impacts of varying the input data used in the stacked prior inventory to disaggregate methane emissions from the MethaneSAT observations for regions outside of the US. The impacts of the inclusion of Carbon Mapper point sources are also not shown. The specific combination of inventories we present in this work are highlighted in the dashed red bars.

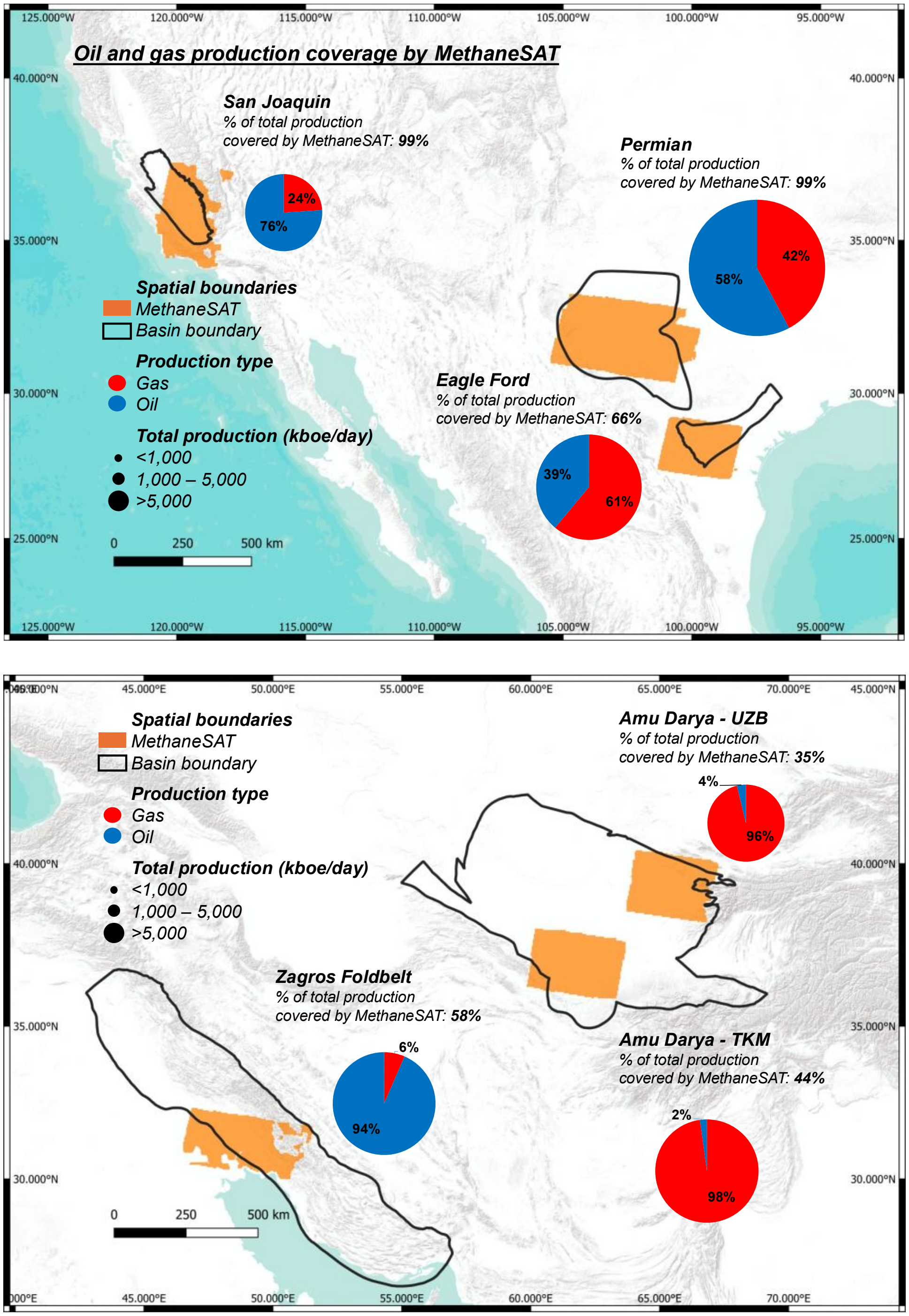

Fig. S9: Map of MethaneSAT aggregated observation domains overlain with spatial boundaries of the primary oil and gas basins associated with the retrievals. The percentage of total oil and gas production contained within the MethaneSAT aggregated observation domains relative to the total production within the oil and gas basin boundaries are shown. The ratios of total oil and gas to total production within the MethaneSAT observed sections of the oil and gas basin are indicated by the pie charts. Basemaps are provides from the ESRI World Terrain basemaps (https://services.arcgisonline.com/ArcGIS/rest/services/World_Terrain_Base/MapServer).

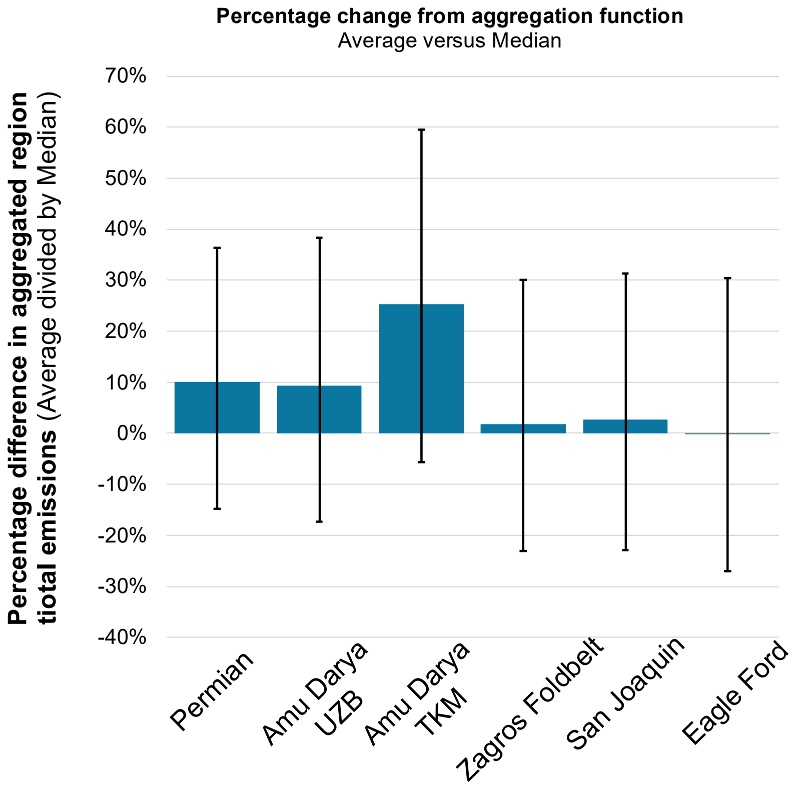

Fig. S10: Sensitivity test showing the percentage difference in total methane emissions estimates after performing the aggregation of MethaneSAT scenes using the median instead of the mean when multiple days of MethaneSAT emissions data are available for a grid cell. The largest difference was found in the Amu Darya – TKM, whereas the Zagros Foldbelt, San Joaquin, and Eagle Ford are relatively unchanged when using the median instead of the mean.

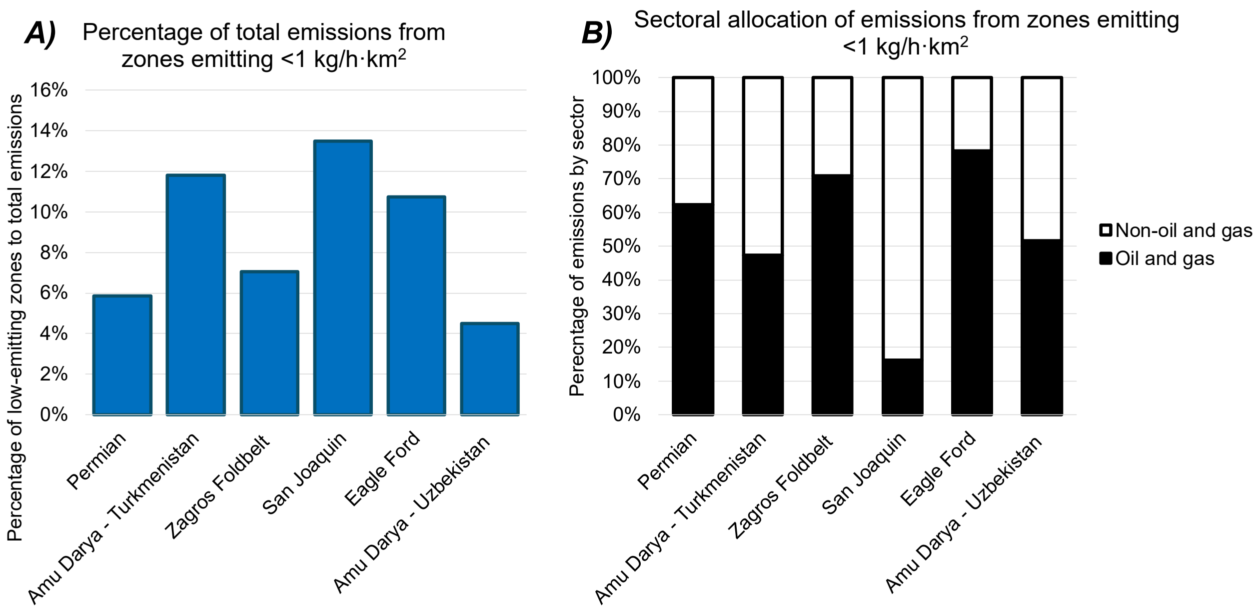

Fig. S11: A) Analysis of the percentage of total methane emissions from the aggregated MethaneSAT emissions estimates originating from low-emitting zones (i.e., single 4 x 4 km grid cells) with emissions below 1 kg/h·km^2. B) Broad sectoral breakdowns of the cumulative emissions from low-emitting zones (<1 kg/h·km^2) based on oil and gas versus non-oil and gas emissions.

Table S1: Description of 33 MethaneSAT observations displaying total methane emissions, total geographic coverage, and emissions for the aggregated observation domains.

Region ID	Retrieval date	Countries	Primary oil and gas basin	Area covered (km^2)	Total methane emissions (t/h) [95% c.i.]	Full observation domain (t/h) [95% c.i.]
A	5/22/2024	USA	Permian	48,000	87 [58 - 121]	454 [351 - 563]
	9/11/2024	USA	Permian	66,000	236 [174 - 307]	
	9/30/2024	USA	Permian	61,000	221 [165 – 282]	
	10/13/2024	USA	Permian	43,000	327 [248 – 412]	
	10/26/2024	USA	Permian	47,000	192 [141 – 252]	
	10/27/2024	USA	Permian	47,000	354 [268 - 446]	
	11/22/2024	USA	Permian	35,000	187 [133 – 249]	
	12/29/2024	USA	Permian	39,000	337 [250 – 438]	
	3/20/2025	USA	Permian	41,000	124 [90 – 162]	
B	11/22/2024	USA / MEX	Eagle Ford	52,000	113 [83 – 148]	114 [83 - 149]
	12/24/2024	USA / MEX	Eagle Ford	16,000	29 [16 – 46]	
	12/25/2024	USA / MEX	Eagle Ford	43,000	84 [56 – 117]	
C	9/12/2024	USA	San Joaquin	30,000	71 [49 – 96]	127 [95 – 162]
	9/25/2024	USA	San Joaquin	21,000	66 [47 – 89]	
	10/20/2024	USA	San Joaquin	17,000	37 [25 – 52]	
	11/21/2024	USA	San Joaquin	15,000	56 [40 – 75]	
	11/22/2024	USA	San Joaquin	12,000	57 [40 – 79]	
	5/8/2025	USA	San Joaquin	24,000	43 [31 – 58]	
D	11/24/2024	UZB / TKM	Amu Darya	35,000	164 [121 – 213]	192 [146 – 242]
	12/27/2024	UZB / TKM	Amu Darya	28,000	154 [112 – 204]	
	1/11/2025	UZB / TKM	Amu Darya	42,000	103 [75 – 134]	
	1/12/2025	UZB / TKM	Amu Darya	32,000	157 [116 – 203]	
	3/19/2025	UZB / TKM	Amu Darya	49,000	187 [132 – 252]	
	5/13/2025	UZB / TKM	Amu Darya	37,000	134 [99 – 174]	
E	9/9/2024	IRN / IRQ	Zagros Foldbelt	18,000	170 [129 – 217]	251 [189 – 321]
	10/19/2024	IRN / IRQ	Zagros Foldbelt	22,000	79 [55 - 106]	
	12/19/2024	IRN / IRQ	Zagros Foldbelt	25,000	177 [134 – 226]	
	3/3/2025	IRN / IRQ	Zagros Foldbelt	36,000	116 [83 – 159]	
	5/10/2025	IRN / IRQ	Zagros Foldbelt	45,000	126 [89 – 171]	
F	7/5/2024	TKM	Amu Darya	60,000	220 [165 – 282]	188 [141 – 239]
	9/30/2024	TKM	Amu Darya	41,000	95 [68 – 128]	
	10/15/2024	TKM	Amu Darya	26,000	83 [60 – 109]	
	5/13/2025	TKM	Amu Darya	19,000	200 [140 – 270]	

Table S2: Breakdown of methane emissions by sector for the aggregated observations domains for each region we present in this work. Uncertainties are provided for each sector. Unknown emissions represent quantified emission estimates from MethaneSAT that are more than 100-times higher than the expected methane emissions from the composite prior inventory.

Region	Sector	Emissions (t/h)	Lower bound (2.5%)	Upper bound (97.5%)
Permian	Oil and gas	408	303	516
	Agriculture	41.4	18.2	64.2
	Waste	1.8	0.8	2.7
	Coal	0	0	0
	Other	2.3	0	4.3
	Unknown	0.4	0.3	0.5
San Joaquin	Oil and gas	30.2	20.3	41.1
	Agriculture	80.8	55.9	106
	Waste	8.9	4.4	12.9
	Coal	0	0	0
	Other	6.8	3.1	10.9
	Unknown	0.0	0.0	0.0
Eagle Ford	Oil and gas	80.0	53.5	110
	Agriculture	27.7	14.9	41.5
	Waste	1.8	0.7	2.8
	Coal	2.2	0	2.0
	Other	1.9	0.9	3.1
	Unknown	0.9	0.6	1.1
Amu Darya Uzbekistan	Oil and gas	99.8	56.7	137
	Agriculture	72.8	42.3	106
	Waste	15.1	10.2	21.1
	Coal	0	0	0
	Other	4.2	2.9	6.1
	Unknown	0	0	0
Amu Darya Turkmenistan	Oil and gas	98.0	64.8	131
	Agriculture	60.2	37.7	85.0
	Waste	23.7	14.5	31.5
	Coal	0	0	0
	Other	5.8	3.9	8.7
	Unknown	0.0	0.0	0.0
Zagros Foldbelt	Oil and gas	203	147	264
	Agriculture	32.6	21.1	45.2
	Waste	9.9	5.8	15.0
	Coal	0	0	0
	Other	5.0	3.2	8.1
	Unknown	0	0	0

Table S3: Breakdown of methane emissions by sector for the aggregated observations domains and larger subregions (i.e., oil and gas basin domains) for each of the six regions we present in this work. Methane intensities normalized by gas- and energy-production are presented for each of the areas. No intensities are presented for "Mexico" as our estimates for oil and gas emissions in that portion of the Eagle Ford observation domain are minimal (i.e., <1 t/h).

Region	Oil and gas	Agriculture	Waste	Coal	Other	Unknown	Energy normalized intensity (kg CH_4/GJ)	Gas-production normalized intensity (%)
Widyan basin	20.2	9.7	3.4	-	0.5	-	0.03	4.2%
Zagros Foldbelt basin	156	22.7	5.9	-	4.1	-	0.24	25.5%
Zagros observation domain	203	32.6	9.9	-	5.0	-	0.16	18.6%
Amu Darya basin	97.0	59.3	23.6	-	5.7	-	0.57	4.1%
Turkmenistan observation domain	98.0	60.2	23.7	-	5.8	-	0.40	2.9%
Amu Darya basin	97.3	67.1	14.1	-	4.1	0.8	0.49	3.6%
Uzbekistan observation domain	99.8	72.8	15.1	-	4.2	-	0.51	3.7%
Mexico	3.2	19.7	0.8	1.4	1.5	-	-	-
USA	71.1	10.1	0.7	0.2	0.9	-	0.19	2.1%
Eagle Ford basin	62.3	5.5	0.1	0.2	0.6	-	0.17	1.9%
Eagle Ford observation domain	80.0	27.7	1.8	2.2	1.9	0.9	0.21	2.4%
San Joaquin basin	25.9	64.1	5.4	-	4.5	-	0.40	15.5%
San Joaquin observation domain	30.2	80.8	8.9	-	6.8	-	0.42	12.1%
New Mexico	66.6	7.4	0.1	-	0.2	-	0.08	1.3%
Texas	338	37.5	1.8	-	2.0	-	0.19	3.1%
Midland subbasin	112	4.6	0.5	-	0.6	-	0.11	2.0%
Delaware subbasin	178	11.7	0.1	-	0.6	-	0.12	2.0%
Permian basin	397	32.2	1.7	-	1.9	0.4	0.15	2.5%
Permian observation domain	408	41.4	1.8	-	2.3	0.4	0.16	2.6%