

Supplementary

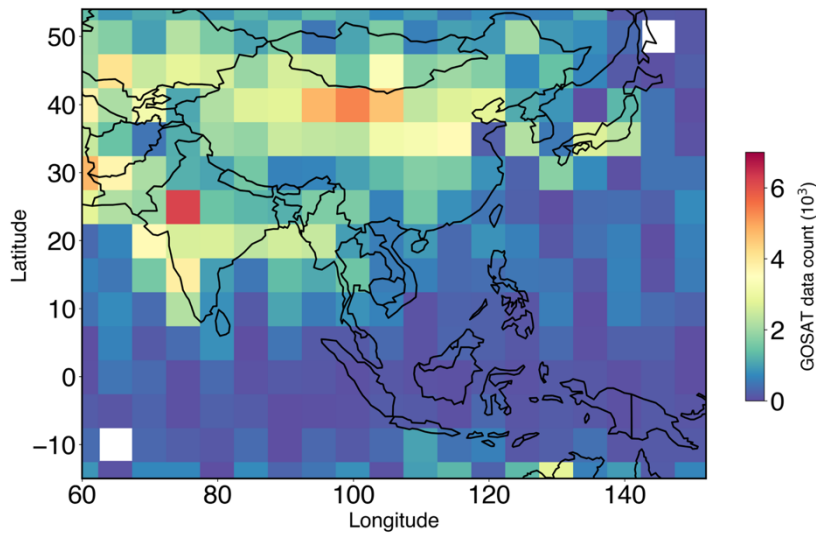


Figure S1: Number of GOSAT observation data during 2010-2021.

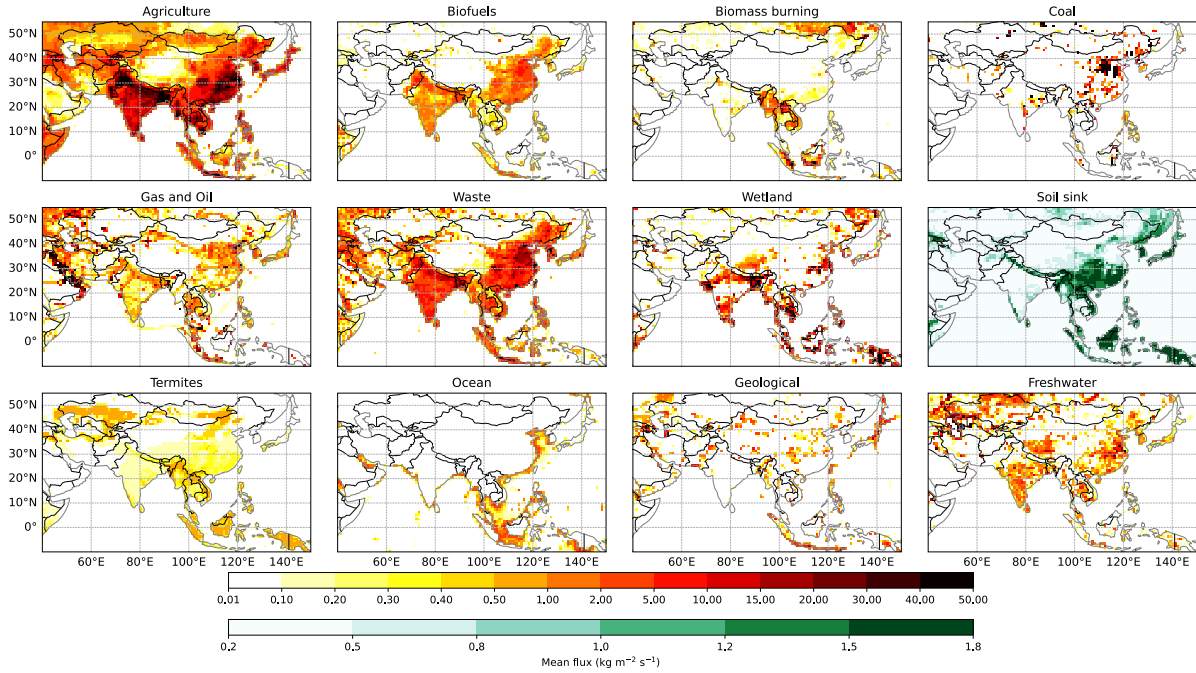


Figure S2: Spatial distributions of prior fluxes.

Table S1: Observation sites from GLOBALVIEWplus CH₄ ObsPack.

Sitename	Station	Nation	Latitude (°E)	Longitude (°N)	Type
abt	Abbotsford	Canada	49.01	-122.34	surface-insitu
alt	Alert	Canada	82.45	-62.51	surface-insitu
amt	Argyle (ME)	United States of America	45.03	-68.68	ship-flask
amy	Anmyeon-do	Republic of Korea	36.54	126.33	surface-insitu
asc	Ascension Island	United Kingdom of Great Britain and Northern Ireland	-7.97	-14.40	surface-flask
ask	Assekrem	Algeria	23.26	5.63	surface-flask

azr	Serreta (Terceira)	Portugal	38.77	-27.38	surface-flask
azv	Azovo	Russia	54.71	73.03	tower-insitu
bck	Behchoko	Canada	62.80	-115.92	surface-insitu
bhd	Baring Head	New Zealand	-41.41	174.87	surface-insitu
bik	Bialystok	Poland	53.20	22.75	surface-flask
bkt	Bukit Kototabang	Indonesia	-0.20	100.32	surface-insitu
bmw	Tudor Hill (Bermuda)	United Kingdom of Great Britain and Northern Ireland	32.27	-64.88	surface-flask
bra	Bratt's Lake Saskatchewan	Canada	50.20	-104.71	surface-insitu
brw	Barrow (AK)	United States of America	71.32	-156.61	ship-insitu
brz	Berezorechka	Russia	56.15	84.33	tower-insitu
bsd	Bilsdale	United Kingdom	54.36	-1.15	tower-insitu
cba	Cold Bay (AK)	United States of America	55.21	-162.72	surface-flask
cby	Cambridge Bay	Canada	69.13	-105.06	surface-insitu
cfa	Cape Ferguson	Australia	-19.28	147.06	surface-flask
cgo	Cape Grim	Australia	-40.68	144.69	surface-flask
chl	Churchill	Canada	58.74	-93.82	surface-insitu
chr	Christmas Island	Kiribati	1.70	-157.15	surface-flask
cib	Centro de Investigacion de la Baja Atmosfera	Spain	41.81	-4.93	surface-flask
coi	Cape Ochiishi	Japan	43.16	145.50	surface-insitu
cps	Chapais, Quebec	Canada	49.82	-74.98	surface-insitu
cpt	Cape Point	South Africa	-34.35	18.49	surface-insitu
cri	Cape Rama	India	15.08	73.83	surface-flask
crz	Crozet	France	-46.43	51.85	surface-flask
cvo	Cape Verde Observatory	Cabo Verde	16.86	-24.87	surface-insitu
cya	Casey	Australia	-66.28	110.52	ship-flask
dem	Demyanskoe	Russia	59.79	70.87	tower-insitu
dsi	Dongsha Island	Taiwan	20.70	116.73	surface-flask
egb	Egbert	Canada	44.23	-79.78	aircraft-insitu
eic	Easter Island	Chile	-27.15	-109.45	surface-flask
eic	Easter Island	Chile	-27.16	-109.43	surface-flask
eom	CONTRAIL*	Japan			surface-flask
esp	Estevan Point	Canada	49.38	-126.54	surface-insitu
est	Esther, Alberta	Canada	51.67	-110.21	surface-insitu
etl	East Trout Lake	Canada	54.35	-104.99	surface-insitu
fne	Fort Nelson, British Columbia	Canada	58.84	-122.57	surface-insitu
fsd	Fraserdale	Canada	49.88	-81.57	tower-insitu
ghg09	United Telephone Mutual Aid Corp	United States	48.67	-98.84	surface-insitu

gmi	Guam (Mariana Island)	United States of America	13.39	144.66	surface-flask
gsn	Gosan	Republic of Korea	33.29	126.16	surface-insitu
hba	Halley	United Kingdom of Great Britain and Northern Ireland	-75.61	-26.21	surface-flask
hnp	Hanlan's Point	Canada	43.61	-79.39	surface-insitu
hpb	Hohenpeissenberg	Germany	47.80	11.02	surface-insitu
hun	Hegyhatsal	Hungary	46.95	16.65	aircraft-flask
ice	Storhofdi	Iceland	63.40	-20.29	surface-flask
inu	Inuvik	Canada	68.32	-133.53	surface-insitu
inx	Indianapolis Flux Experiment	United States	39.58	-86.42	surface-pfp
izo	Izaña (Tenerife)	Spain	28.31	-16.50	surface-insitu
jfj	Jungfraujoch	Switzerland	46.55	7.99	surface-insitu
jgs	Jejudo Gosan Suwolbong	Republic of Korea	33.30	126.16	surface-insitu
key	Key Biscane (FL)	United States of America	25.66	-80.16	surface-flask
kum	Cape Kumukahi (HI)	United States of America	19.52	-154.82	surface-flask
lef	Park Falls (WI)	United States of America	45.95	-90.27	tower-flask
lew	Lewisburg	United States	40.95	-76.88	surface-pfp
llb	Lac La Biche (Alberta)	Canada	54.95	-112.47	surface-insitu
lln	Lulin	Taiwan, Province of China	23.47	120.87	surface-flask
lmp	Lampedusa	Italy	35.52	12.62	surface-flask
maa	Mawson	Australia	-67.62	62.87	surface-flask
mbo	Mt. Bachelor Observatory	United States	43.98	-121.69	surface-pfp
mex	Mex High Altitude Global Climate Observation Center	Mexico	18.98	-97.31	surface-flask
mhd	Mace Head	Ireland	53.33	-9.90	surface-insitu
mid	Sand Island	United States of America	28.21	-177.38	surface-flask
mlo	Mauna Loa (HI)	United States of America	19.54	-155.58	surface-flask
mmn	Minamitorishima	Japan	24.29	153.98	ship-insitu
mqa	Macquarie Island	Australia	-54.48	158.97	surface-flask
mwo	Mt. Wilson Observatory	United States	34.23	-118.06	surface-pfp
nam	Gobabeb	Namibia	-23.56	15.05	surface-flask
nat	Natal	Brazil	-5.51	-35.26	surface-flask
nat	Natal	Brazil	-5.79	-35.19	surface-flask
nmb	Gobabeb	Namibia	-23.58	15.03	ship-flask
noy	Noyabrsk	Russia	63.43	75.78	tower-insitu
nwr	Niwot Ridge - T-van (CO)	United States of America	40.05	-105.58	aircraft-flask

nwr	Niwot Ridge - T- van (CO)	United States of America	40.05	-105.59	aircraft-flask
oxk	Ochsenkopf	Germany	50.03	11.81	surface-flask
pal	Pallas	Finland	67.97	24.12	surface-insitu
pdi	Pha Din	Viet Nam	21.57	103.52	aircraft-insitu
pip	Pacific coast	Japan			Aircraft-flask
poc	Pacific Ocean	Japan			shipboard-flask
psa	Palmer Station	United States of America	-64.77	-64.05	surface-flask
rgl	Ridge Hill	United Kingdom of Great Britain and Northern Ireland	52.00	-2.54	surface-insitu
rpb	Ragged Point	Barbados	13.16	-59.43	ship-flask
ryo	Ryori	Japan	39.03	141.82	ship-insitu
san	Santarem	Brazil			surface-flask
sct	Beech Island	United States	33.41	-81.83	tower-insitu
sdz	Shangdianzi	China	40.65	117.12	surface-flask
sey	Mahé	Seychelles	-4.68	55.53	surface-flask
sgp	Southern Great Plains E13	United States of America	36.80	-97.50	surface-flask
shm	Shemya Island	United States of America	52.72	174.10	surface-flask
sis	Shetland Islands	Scotland	60.09	-1.25	surface-flask
smo	Samoa (Cape Matatula)	United States of America	-14.25	-170.56	surface-flask
spo	South Pole	United States of America	-89.98	-24.80	surface-flask
sum	Summit	Denmark	72.60	-38.42	surface-flask
syo	Syowa	Japan	-69.01	39.59	tower-flask
tac	Tacolneston Tall Tower	United Kingdom of Great Britain and Northern Ireland	52.52	1.14	aircraft-insitu
tap	Tae-ahn Peninsula	Republic of Korea	36.73	126.13	surface-flask
tda	Japan				Aircraft-flask
tik	Tiksi	Russian Federation	71.60	128.89	surface-flask
tpd	Turkey Point	Canada	42.63	-80.56	surface-insitu
ush	Ushuaia	Argentina	-54.85	-68.31	surface-flask
uta	Wendover	United States of America	39.90	-113.72	surface-flask
uum	Ulaan Uul	Mongolia	44.45	111.10	surface-flask
vgn	Vaganovo	Russia	54.50	62.33	tower-insitu
wbi	West Branch	United States	41.73	-91.35	surface-pfp
wgc	Walnut Grove	United States	38.26	-121.49	tower-insitu
wis	Sede Boker	Israel	30.86	34.78	surface-flask
wkt	Moody	United States of America	31.32	-97.33	ship-flask
wlg	Mt. Waliguan	China	36.29	100.90	surface-flask
wpc	Western Pacific Cruise				shipboard-flask
wsa	Sable Island	Canada	43.93	-60.01	surface-insitu

yon	Yonagunijima	Japan	24.47	123.01	surface-insitu
zep	Zeppelin Mountain	Norway	78.91	11.89	surface-flask
zot	Zotino	Russia	60.75	89.38	surface-flask

Table S2: Additional observation sites in Asia.

sitename	station, nation	Latitude (°E)	Longitude (°N)	altitude	type	data source	Data_Set_Version/DOI/reference
akd	akedala, China	47.10	87.93	562.00	surface-flask	CMA ^a	Zhang et al., 2022b
jsa	jinsha, China	29.63	114.22	750.00	surface-flask	CMA	Zhang et al., 2022b
lan	Lin an, China	30.30	119.72	138.60	surface-insitu	CMA	Zhang et al., 2022b
lfs	Longfenshan, China	44.73	127.60	330.50	surface-insitu	CMA	Zhang et al., 2022b
sdz	Shangdianzi, China	40.65	117.12	293.30	surface-insitu	CMA	Zhang et al., 2022b
xgl	Xianggelila, China	28.00	99.40	3580.00	surface-insitu	CMA	Zhang et al., 2022b
dcd	Qinghai	41.84	109.64		balloon	CMA	
nmg	Nei Menggu	41.82	109.51		balloon	CMA	
cla	Comilla, Bangladesh	23.43	91.18	30.00	surface-flask	NIES ^b	10.17595/20220301.004 ^e
coi	Cape Ochi-ishi, Japan	43.16	145.50	94.00	surface-insitu	NIES	10.17595/20160901.004 ^f
hat	Hateruma, Japan	24.06	123.81	10.80	surface-insitu	NIES	10.17595/20160901.003 ^g
ntl	Nainita, India	29.36	79.46	1940.00	surface-flask	NIES	10.17595/20220301.003 ^h
uld	Ulleungdo, Korea	130.90	37.48	220.90	surface-insitu	KMA ^c	
aoa	Western North Pacific, Japan				aircraft-flask	WDCGG ^d	0001-8002-1002-05-02-9999 2023-09-19-0647
nwp	Northern and western Pacific, Japan				shipboard-flask	WDCGG	0070-8036-1002-06-02-9999 2023-01-26-0918
pdi	Pha Din, Viet Nam	21.57	103.52	1478.00	surface-insitu	WDCGG	0051-2035-1002-01-01-9999 2023-08-22-1120
gsn	Gosan, Korea	33.29	126.16	71.39	surface-insitu	WDCGG	0039-2025-1002-01-01-9999 2023-08-01-1133
bsl	Pacific Ocean, New Zealand				shipboard-flask	WDCGG	0057-8023-1002-06-02-9999 2019-10-16-1145

a: China Meteorology Administration; b: National Institute of Environmental Studies; c: Korea Meteorology Administration;

d: World Data Centre for Greenhouse Gases

e: Terao, Y., Nomura, S., Mukai, H., Machida, T., Sasakawa, M., Ahmed, M. K., and Patra, P. K. (2022), Atmospheric Methane Dry Air Mole Fraction at Comilla, Bangladesh, ver.2022.0, NIES, DOI:10.17595/20220301.004. (Reference date: 2023/05/29)

f: Tohjima et al. (2002), Analysis and presentation of in situ atmospheric methane measurements from Cape Ochi-ishi and Hateruma Island, J. Geophys. Res., 107, 4148, DOI:10.1029/2001JD001003. (Reference date: 2023/05/29)

g: Tohjima, Y., M. Sasakawa, N. Tsuda, and T. Machida (2016), Continuous observational data of atmospheric CH₄ mixing ratios on Hateruma Island, Ver. 1.6, NIES, DOI:10.17595/20160901.003. (Reference date: 2023/05/29)

h: Terao, Y., Nomura, S., Mukai, H., Machida, T., Sasakawa, M., and Naja, M. (2022), Atmospheric Methane Dry Air Mole Fraction at Nainital, India, ver.2022.0, NIES, DOI:10.17595/20220301.003. (Reference date: 2023/05/29)

Table S3: Comparison of national totals in EDGAR table and grid files with different masks.

Country	Edgar V7 table (Gt)	Edgar-land (Gt)	Edgar-eez (Gt)	changes (%)
China	66.62	64.83	66.8	3.03
India	30.27	29.77	30.06	0.99

Indonesia	13.52	12.50	13.40	7.15
Pakistan	8.30	8.25	8.26	0.12
Bangladesh	4.98	4.74	4.94	4.30
Vietnam	4.5	4.07	4.41	8.37
Thailand	4.71	4.31	4.62	7.05
Myanmar	3.61	3.31	3.57	7.88
Philippines	2.90	2.55	2.83	11.01
Japan	2.19	2.03	2.22	9.22
South Korea	1.63	1.54	1.64	6.18
Malaysia	2.00	0.80	1.81	124.78
Mongolia	1.01	1.01	1.01	-0.08
Nepal	1.20	1.17	1.16	-0.29
Cambodia	0.95	0.91	0.91	0.02
North Korea	0.82	0.81	0.83	1.58

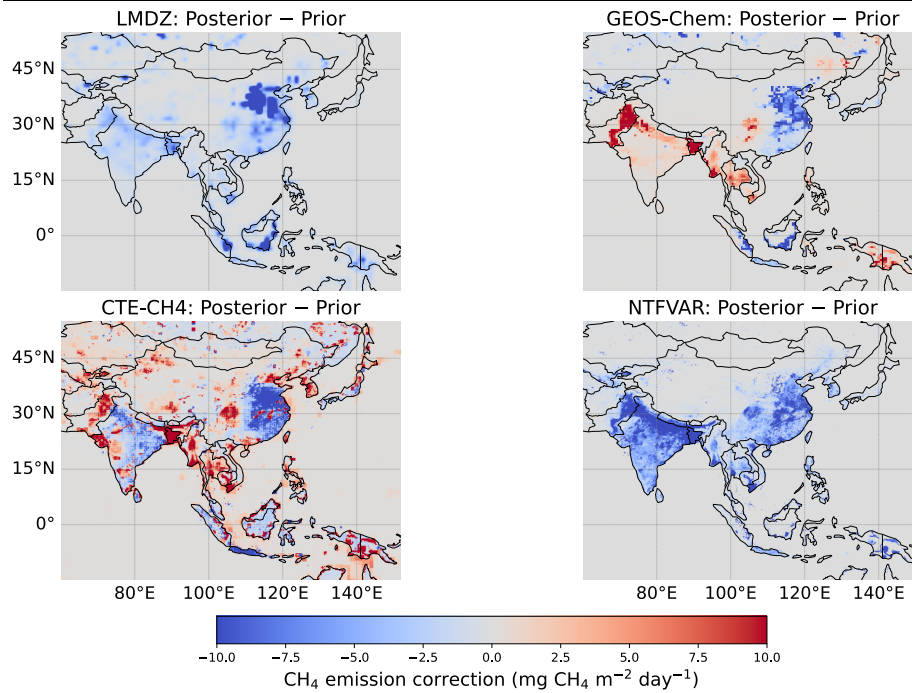


Figure S3: Spatial distribution of model-specific posterior corrections, calculated for averaged CH₄ fluxes corrections (posterior minus prior) constrained by GOSAT-only observations (SURF) for the simulation periods.