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Supporting Information for

Interpreting the seasonality of atmospheric methane

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Introduction

Tables S1 and S2 and Figures S1 to S3 are included below to supplement the main manuscript. Descriptions of each figure and table are included in the caption.

Table S1:OH simulation ensemble members.

Project	**Model**	**Experiment**	**$[OH]_{GM}$** Air mass weighted 10^5 molecules cm^{-3}	**NH/SH**
-	GEOS-Chem default		10.0	1.07
-	GEOS-Chem (NH/SH best estimate)		10.0	0.97
-	GEOS-Chem (NH/SH low estimate)		10.0	0.85
-	GEOS-Chem (+10%)		11.0	1.07
-	GEOS-Chem (-10%)		9.0	1.07
ACCMIP	CESM-CAM-superfast	acchist	8.6	1.40
ACCMIP	CICERO-OsloCTM2	acchist	8.3	1.35
ACCMIP	CMAM	acchist	8.9	1.17
ACCMIP	EMAC	acchist	9.5	1.09
ACCMIP	GEOSCCM	acchist	9.9	1.14
ACCMIP	GFDL-AM3	acchist	9.4	1.17
ACCMIP	GISS-E2-R	acchist	8.6	1.20
ACCMIP	MIROC-CHEM	acchist	9.1	1.26
ACCMIP	MOCAGE	acchist	8.6	1.21
ACCMIP	NCAR-CAM3.5	acchist	8.9	1.32
ACCMIP	STOC-HadAM3	acchist	8.2	1.30
ACCMIP	UM-CAM	acchist	9.3	1.34
CCMI	CHASER-MIROC-ESM	REF-C1SD	9.1	1.19
CCMI	CMAM	REF-C1SD	9.1	1.16
CCMI	EMAC-L47MA	REF-C1SD	9.9	1.18
CCMI	EMAC-L90MA	REF-C1SD	9.6	1.20
CCMI	MOCAGE	REF-C1SD	8.2	1.23

Experiments for ACCMIP are described in Lamarque et al. (2013) and experiments for CCMI are described in Orbe et al. (2020). All models are weighted by the same GEOS-Chem atmosphere.

Table S2: Annual wetland emissions in latitude bands and month of boreal peak.

Wetland inventory	Global total [Tg]	-90 to -10 [Tg]	-10 to 10 [Tg]	10 to 35 [Tg]	35 to 90 [Tg]	Boreal peak month
WetCHARTs HP-mean	140	14	82	11	33	July
LPJ-wsl CRU	204	30	115	33	26	August
LPJ-wsl ERA5	158	22	73	21	43	August
LPJ-wsl ERA5-MSWEP	156	20	73	21	41	August
LPJ-wsl MERRA-2	192	27	84	31	48	August
UpCH4	150	47	31	41	31	July
WetCHARTs 1913 (HP)	128	10	58	10	49	July
WetCHARTs 1914 (HP)	125	12	67	8	38	July
WetCHARTs 1923 (HP)	126	13	76	13	25	July
WetCHARTs 1924 (HP)	124	13	84	10	18	July
WetCHARTs 1933 (HP)	126	14	81	14	17	July
WetCHARTs 1934 (HP)	125	14	88	10	12	July
WetCHARTs 2913 (HP)	170	13	78	14	66	July
WetCHARTs 2914 (HP)	167	16	90	10	50	July
WetCHARTs 2923	169	17	101	18	33	July
WetCHARTs 2924 (HP)	166	18	112	13	24	July
WetCHARTs 2933	169	18	108	19	23	July
WetCHARTs 2934	166	18	118	14	16	July
WetCHARTs 3913	213	16	97	17	82	July
WetCHARTs 3914	208	20	112	13	63	July
WetCHARTs 3923	211	21	126	22	42	July
WetCHARTs 3924	207	22	140	16	30	July
WetCHARTs 3933	211	23	135	24	29	July
WetCHARTs 3934	208	23	147	17	20	July

WetCHARTs inventories including “HP” are part of the high-performing ensemble identified by Ma et al. (2021) and are used to create the high-performing mean inventory. Latitude totals may not sum exactly to global total due to rounding.

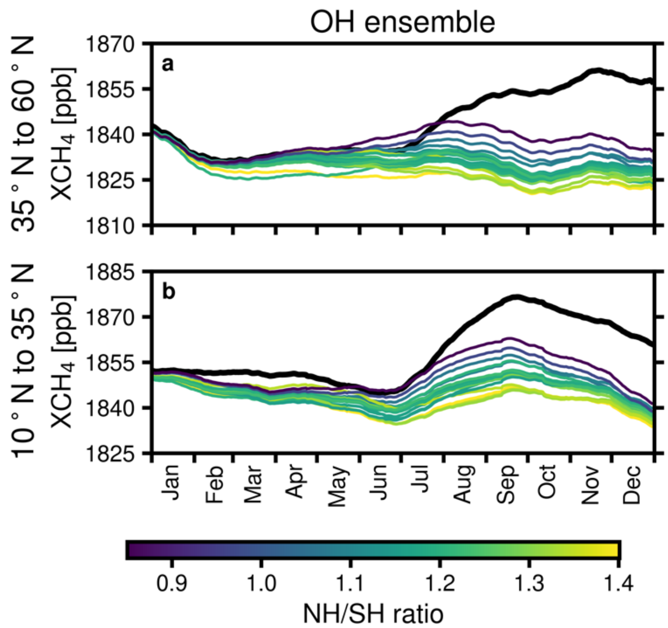

Figure S1: Modeled and observed of dry air column mole fraction of methane (XCH_4), zonally averaged in the latitude bands 10°N-35°N and 35°N-60°N. Black, bold curves represent observations from TROPOMI+GOSAT. Panels (a) and (b) show results for the OH ensemble with each curve representing results from a different GEOS-Chem simulation using OH from a different model colored by NH/SH ratio.

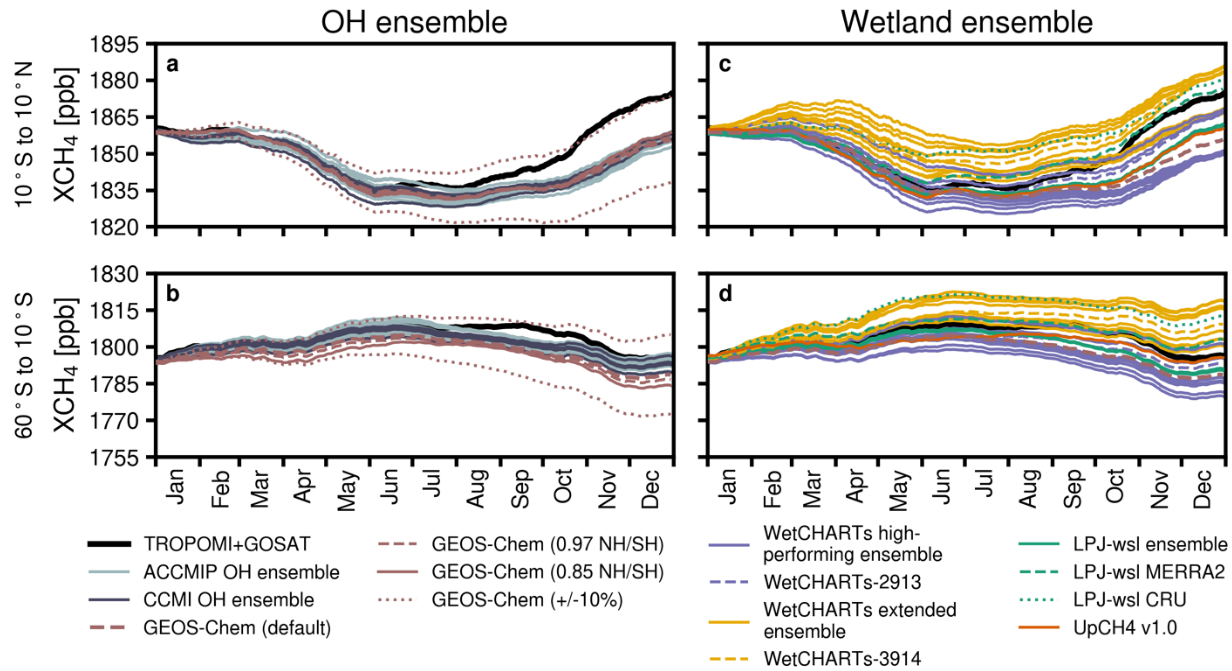

Figure S2: Seasonality of methane for ensembles of OH and wetland simulations, compared to TROPOMI+GOSAT observations at 60°S-10°S and 10°S-10°N. Panels (a) and (b) show results for the OH ensemble with each curve representing results from a different model, and panels (c) and (d) show results for the wetland emissions ensemble. All OH models have been normalized to yield a methane lifetime of 11.2 years against oxidation by tropospheric OH. Red lines in panels (a) and (b) show GEOS-Chem with its default OH, which has a NH/SH ratio of 1.07, and additional simulations with the NH/SH ratio adjusted to 0.97 and 0.85. Dashed and dotted lines in panels (c) and (d) show XCH_4 simulated with selected wetland ensemble members including WetCHARTs-2913, LPJ-wsl MERRA-2, and LPJ-wsl CRU.

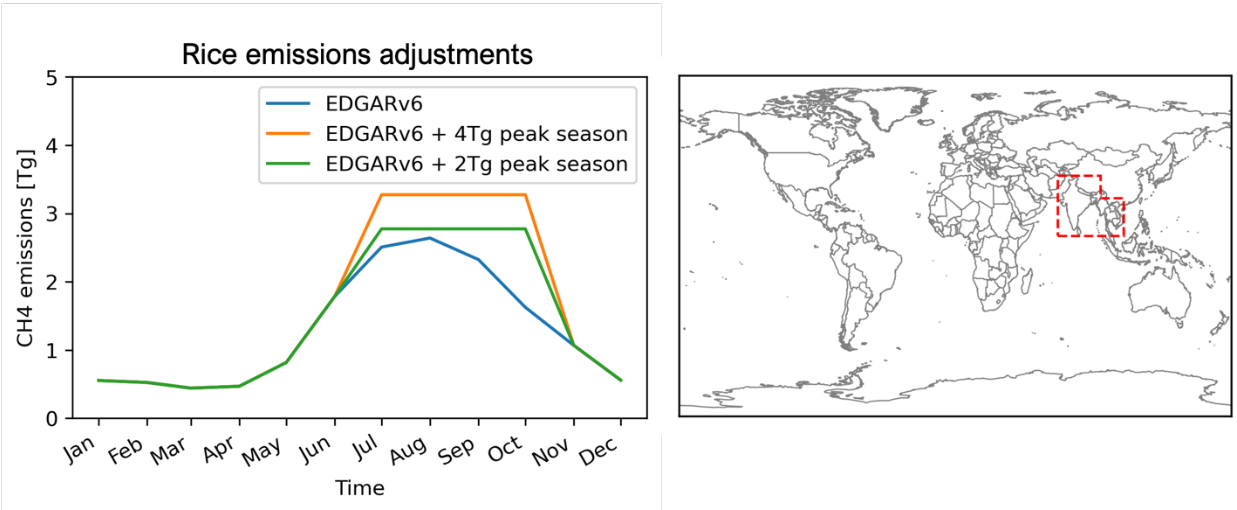

Figure S3: Rice emissions adjustment applied to GEOS-Chem prior emissions, which are EDGARv6. Adjustments are applied only within the red box on the right panel, encompassing India and Southeast Asia. Adjustments increase annual global rice emissions by 4 Tg for the orange line and 2 Tg for the green line.

References

Lamarque, J. F., Shindell, D. T., Josse, B., Young, P. J., Cionni, I., Eyring, V., et al. (2013). The atmospheric chemistry and climate model intercomparison Project (ACCMIP): Overview and description of models, simulations and climate diagnostics. *Geoscientific Model Development*, *6*(1), 179–206. https://doi.org/10.5194/gmd-6-179-2013

Ma, S., Worden, J. R., Bloom, A. A., Zhang, Y., Poulter, B., Cusworth, D. H., et al. (2021). Satellite Constraints on the Latitudinal Distribution and Temperature Sensitivity of Wetland Methane Emissions. *AGU Advances*, *2*(3). https://doi.org/10.1029/2021AV000408

Orbe, C., Plummer, D. A., Waugh, D. W., Yang, H., Jöckel, P., Kinnison, D. E., et al. (2020). Description and Evaluation of the specified-dynamics experiment in the Chemistry-Climate Model Initiative. *Atmospheric Chemistry and Physics*, *20*(6), 3809–3840. https://doi.org/10.5194/acp-20-3809-2020