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Supplement of

A Global Database of Soil Methane Uptake (SMUD)

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Supplementary Information for

A Global Database of Soil Methane Uptake (SMUD)

This PDF file includes:

Figures S1-S9

Table S1

Supplementary methods

Other supplementary materials for this manuscript include the following:

Supplementary file “Studies and Fluxes”

Supplementary file “CH4 uptake data_CH4 FLUX_1_1410”

Supplementary MATLAB code 1 (CH_4)

Supplementary MATLAB code 2 (soil moisture)

Supplementary MATLAB code 3 (soil temperature)

Supplementary R code Figs. 1-5 and Figs. S1-S9

Additional files were also prepared to support calculations and figure generation.

Supplementary Information

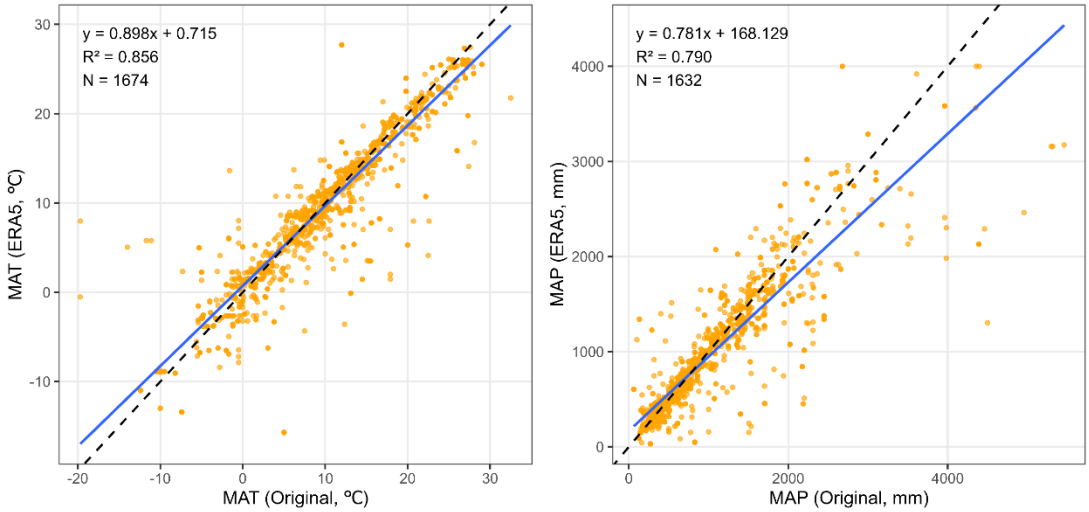


Figure S1. Comparison of extracted and original values of mean annual temperature (MAT) and mean annual precipitation (MAP) obtained from the ERA5-Land Monthly Aggregated dataset.

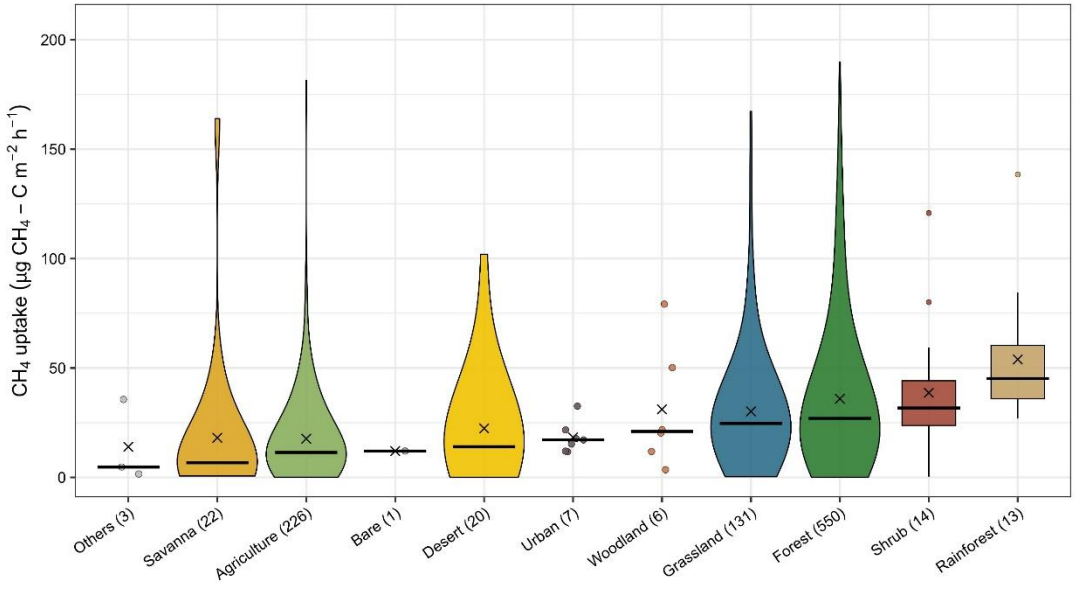


Figure S2. Comparison of annual soil methane uptake observations across ecosystems: Savanna, Agriculture, Bare, Desert, Urban, Others, Woodland, Grassland, Forest, Shrubland, and Rainforest. The black lines indicate the median CH_4 uptake and the crosses (×) denote the mean for each ecosystem. The biomes are ordered by the median SMU values. The count of flux values is indicated following each x-axis label. In violin plots, the width represents the kernel density of observations at a given value. Plot types were selected based on sample size: scatter plots for <10, box plots for 10-20, and violin plots for ⩾20.

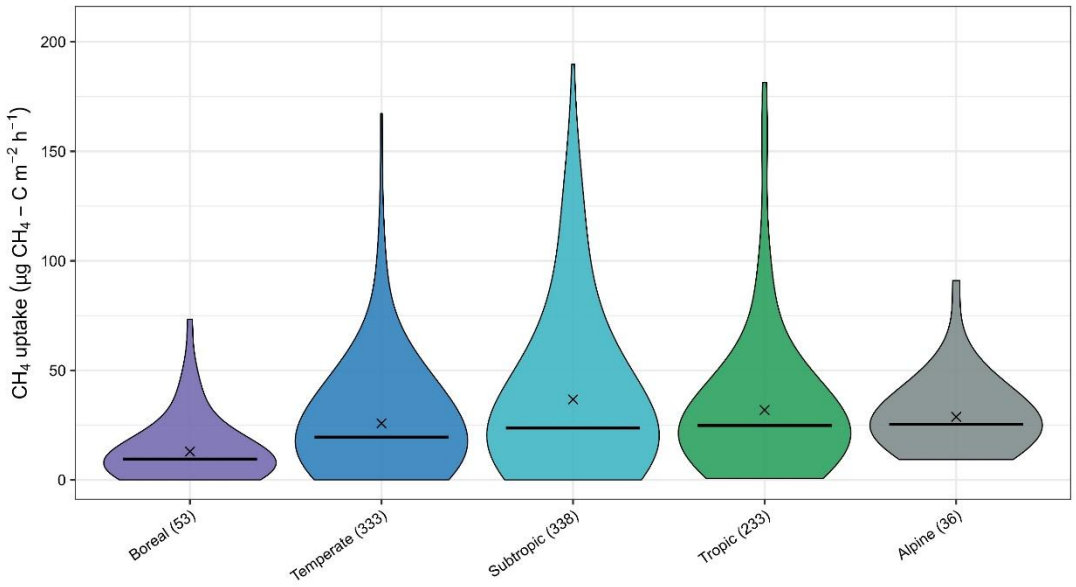


Figure S3. Comparison of annual soil methane uptake observations across climate zones: Boreal, Temperate, Subtropic, Tropic, and Alpine. The black lines indicate the median CH_4 uptake and the cross (×) denote the mean for each biome. The biomes are ordered by the median SMU values. The count of flux values is indicated following each x-axis label. In violin plots, the width represents the kernel density of observations at a given value.

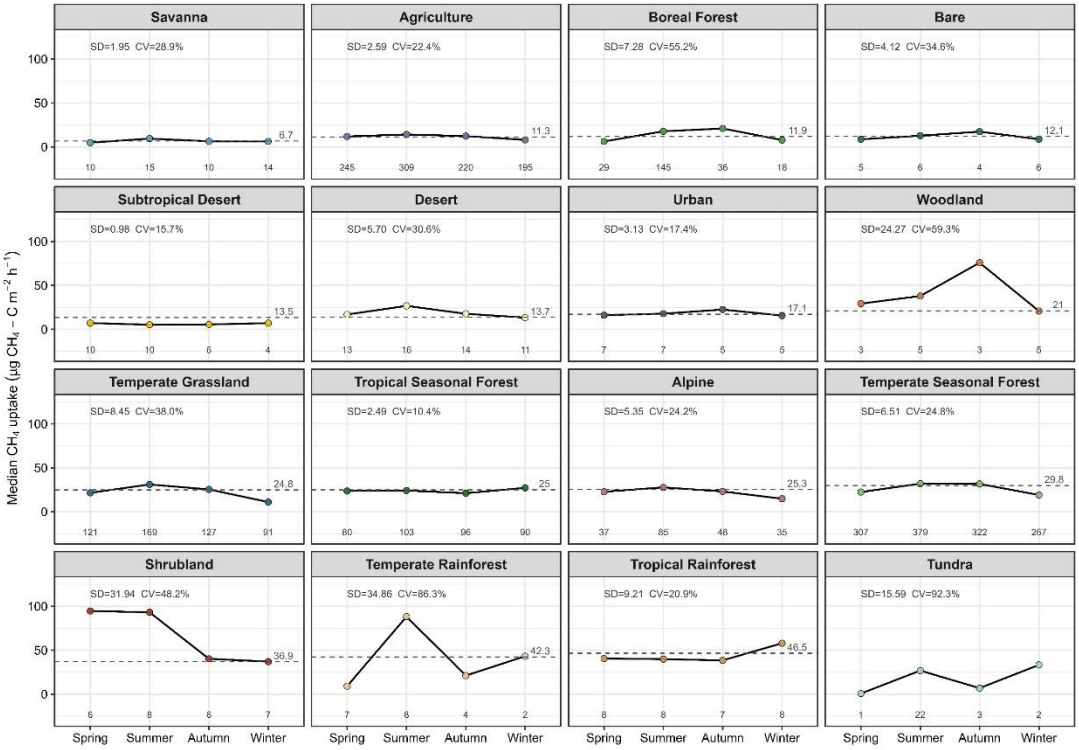


Figure S4. Seasonal variations of soil methane uptake across biomes compared with annual median values. Dashed lines indicate annual median soil methane uptake for each biome.

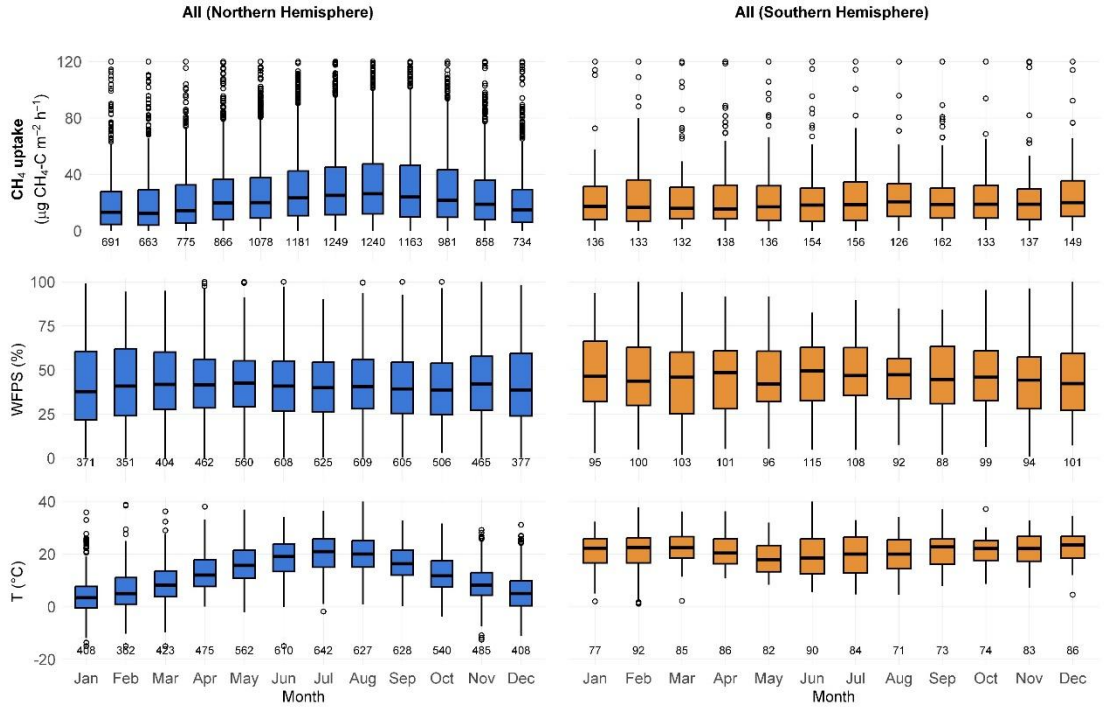
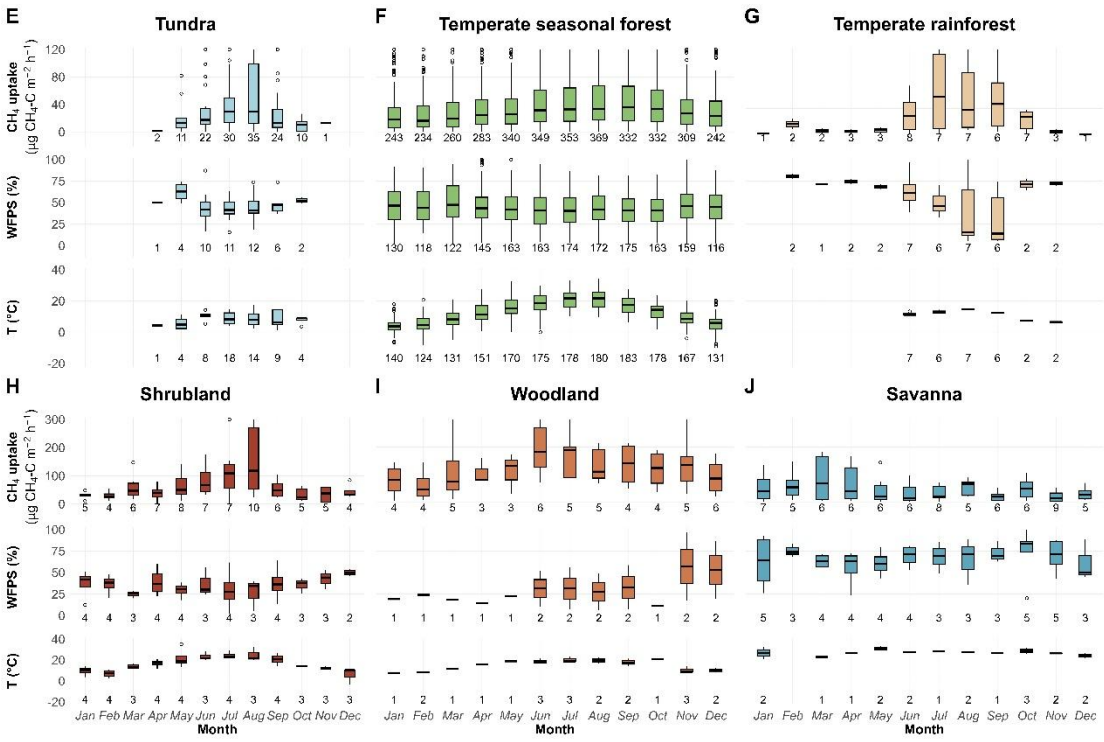


Figure S5. Intra-annual variations of soil methane uptake, soil moisture (expressed as WFPS, water-filled pore space), and soil temperature (T) across biomes in the Northern and Southern Hemispheres. The black lines indicate the median CH_4 uptake across all biomes. The count of flux values in each month is labeled beneath the x-axis ticks.



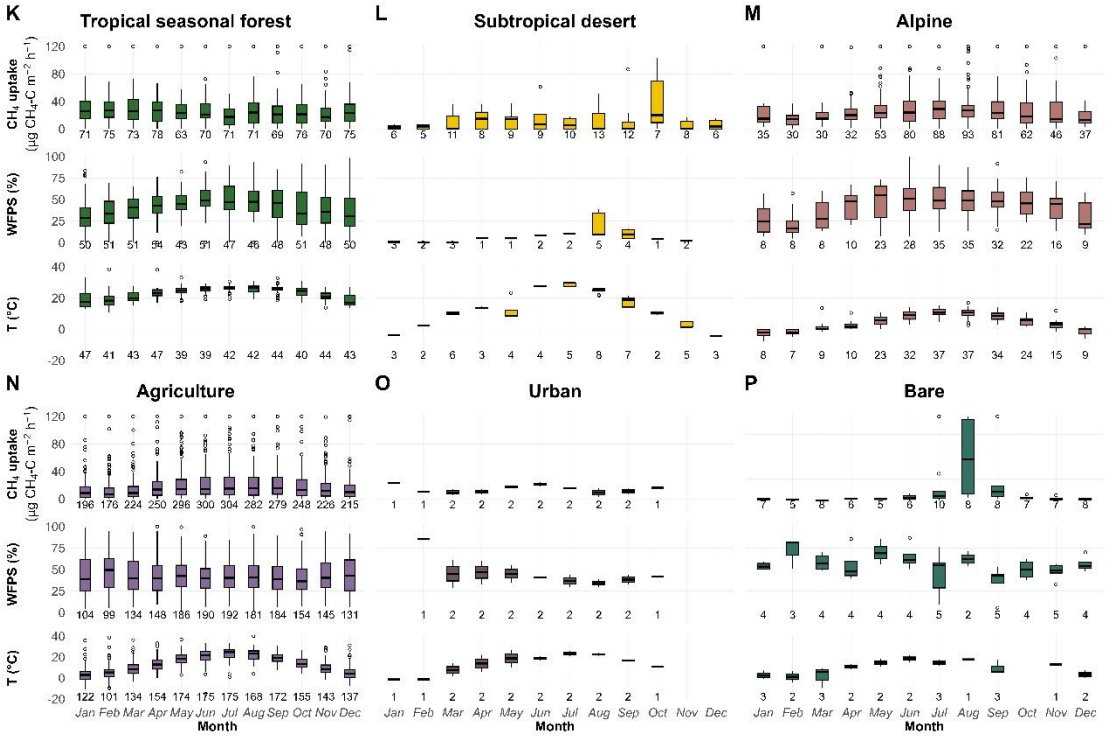


Figure S6. Intra-annual variations of soil methane uptake, soil moisture (expressed as WFPS, water-filled pore space), and soil temperature (T) across the additional biomes following Fig. 5 in the Northern Hemisphere. The black lines indicate the median CH_4 uptake for each biome, with the corresponding values labeled above. The count of flux values in each month is labeled beneath the x-axis ticks.

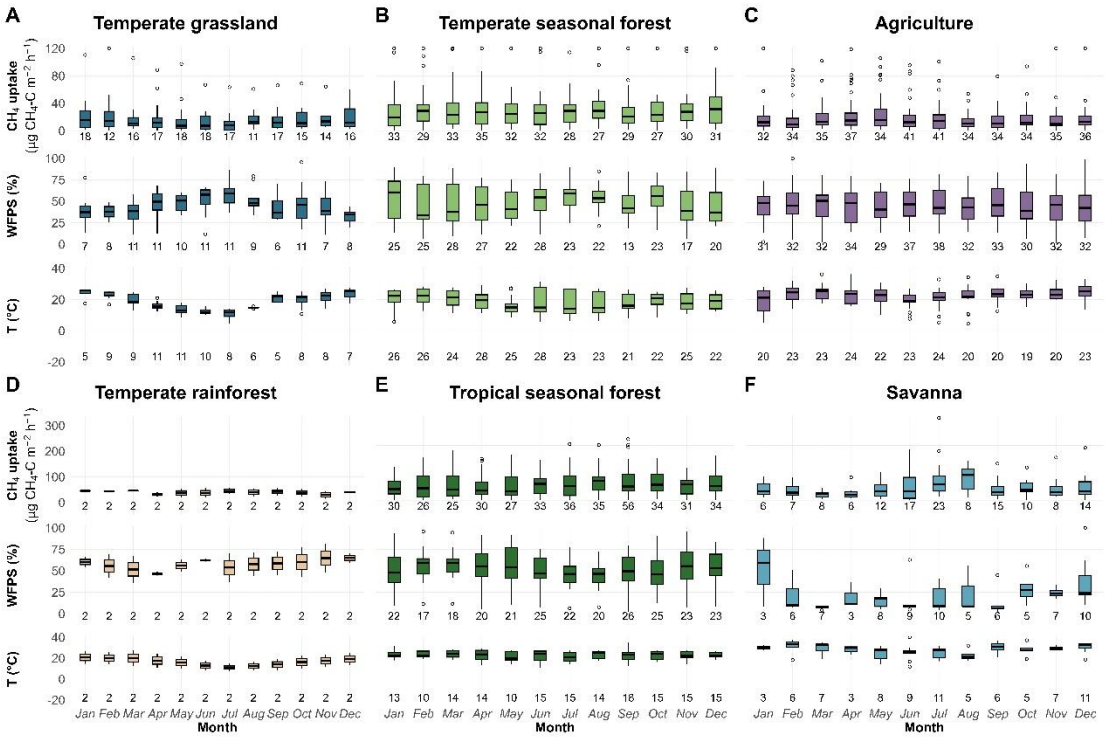
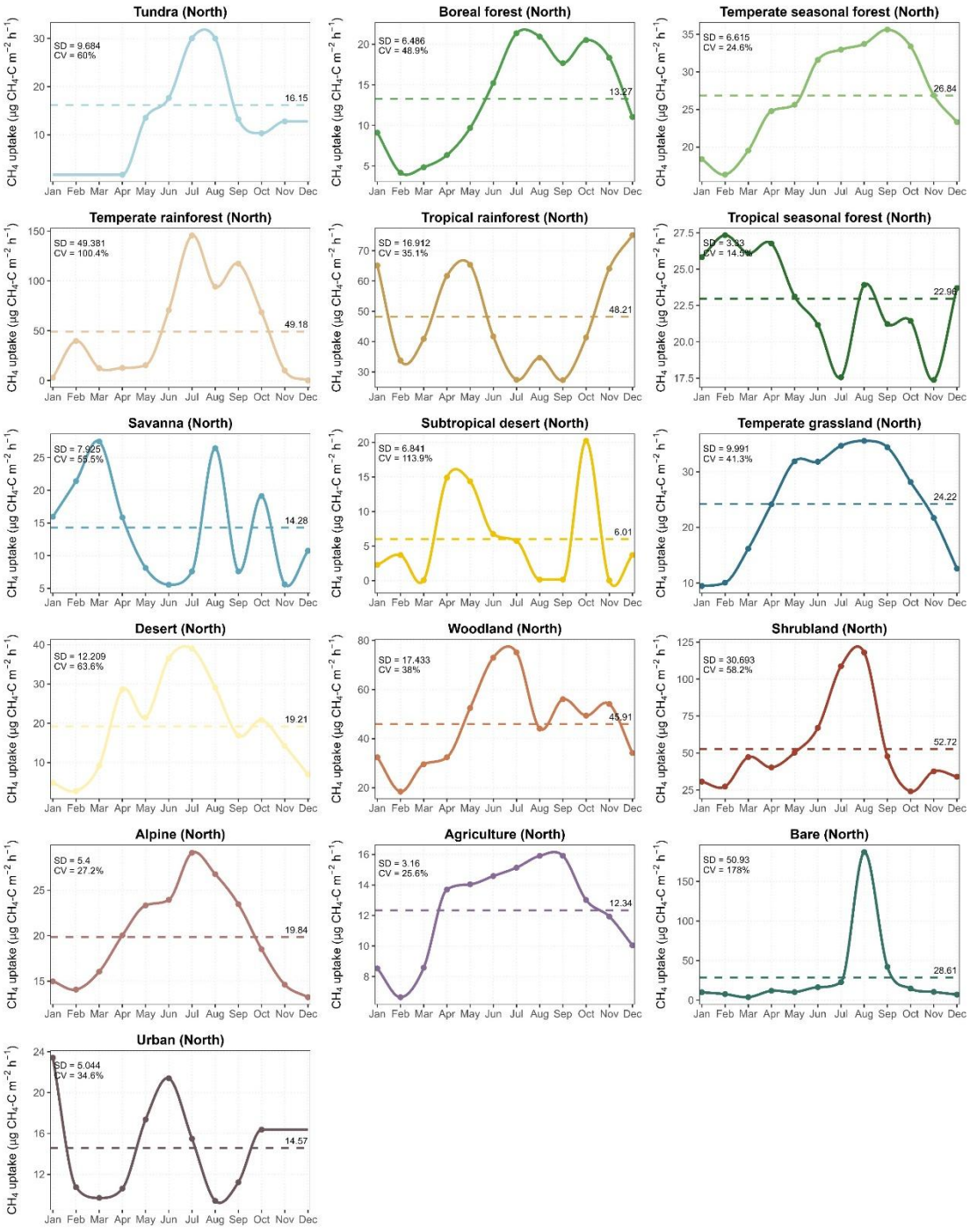


Figure S7. Intra-annual variations of soil methane uptake, soil moisture (expressed as WFPS, water-filled pore space), and soil temperature (T) across biomes in the Southern Hemisphere,

which includes only those biomes with more than one observation for each month (Jan-Dec) in CH_4 uptake, soil moisture, and soil temperature. The black lines indicate the median CH_4 uptake for each biome, with the corresponding values labeled above. The count of flux values in each month is labeled beneath the x-axis ticks.



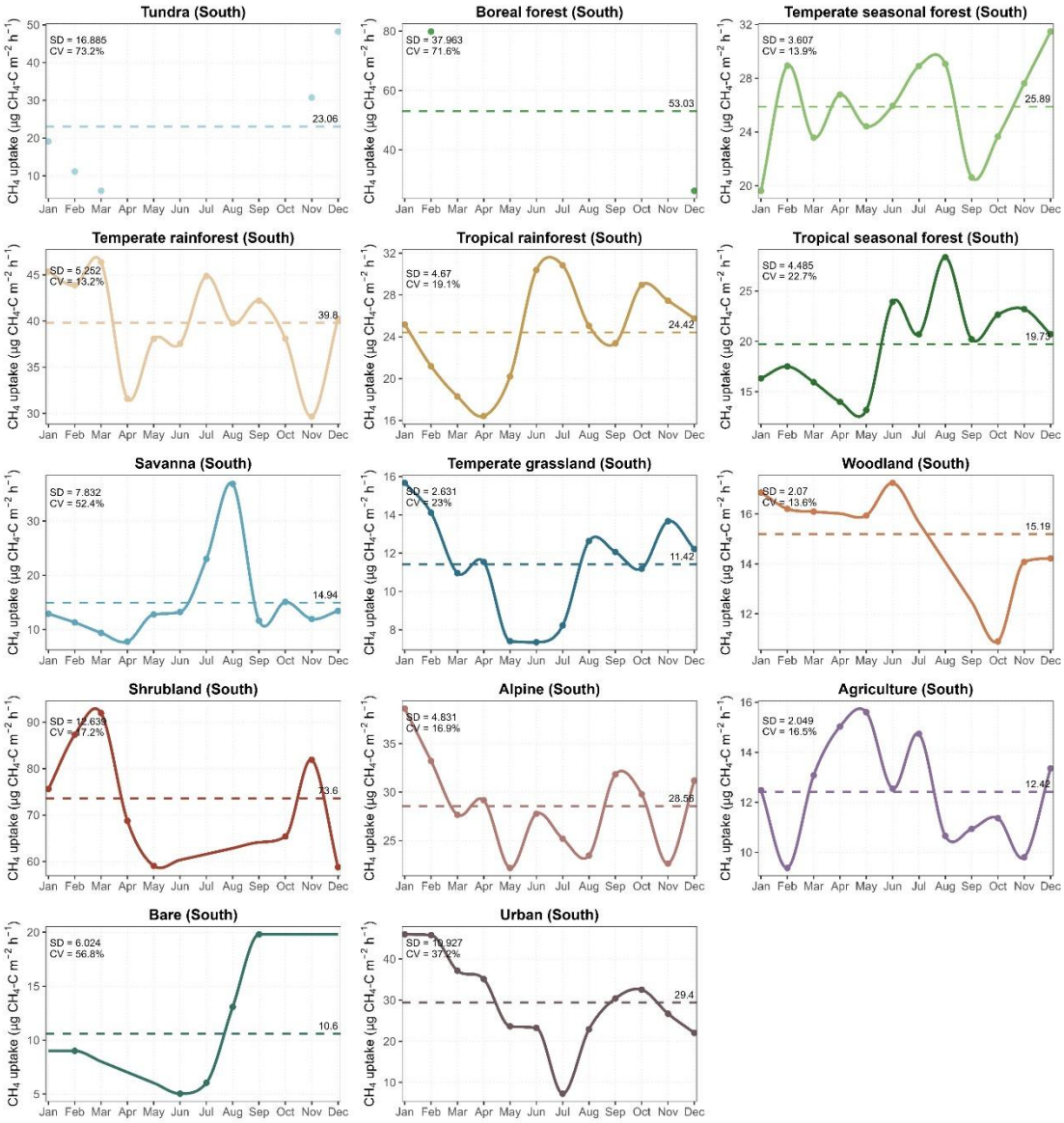


Figure S8. Comparison of monthly median soil methane uptake values (Jan-Dec) with the annual mean of monthly medians across biomes. The dashed lines represent the mean of the Jan-Dec values. The smoothed curves represent interpolated seasonal trajectories derived from monthly median CH_4 uptake values, intended to visualize typical intra-annual patterns rather than to infer temporal trends or model fits.

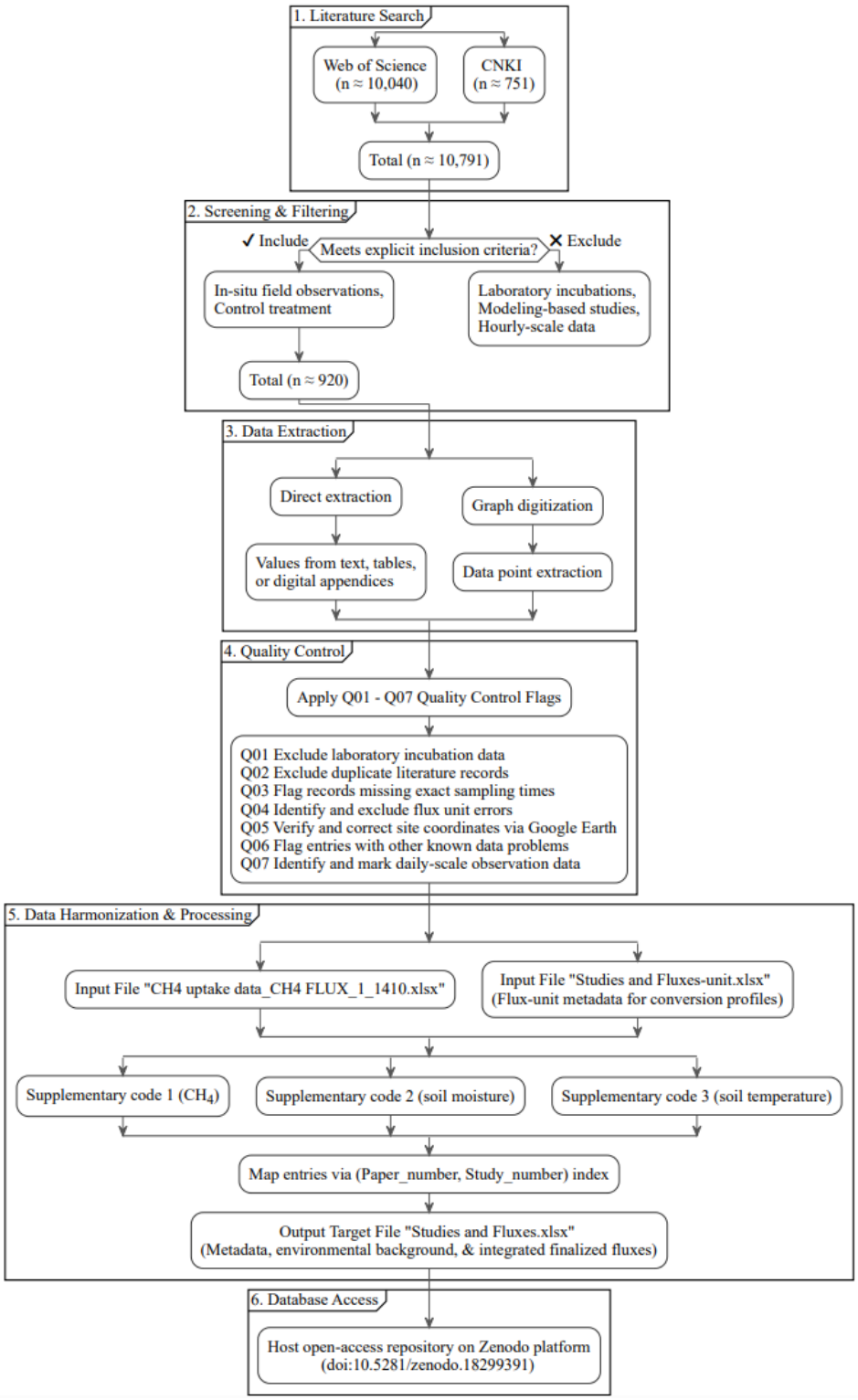


Figure S9. Workflow of the SMUD data compilation and processing pipeline.

Table S1 Standardized multiple regression analysis used to classify the relative controls of soil temperature and soil moisture on soil methane uptake across ecosystems.

Ecosystem	n	Dominance	beta_ST	p_ST	beta_SM	p_SM	abs_beta_ST/abs_beta_SM
Tundra	38	Moisture-dominated	0.095	0.535	-0.515	0.002	0.185
Boreal forest	224	Moisture-dominated	-0.047	0.465	-0.344	0.000	0.137
Temperate seasonal forest	1748	Moisture-dominated	0.041	0.076	-0.234	0.000	0.177
Temperate rainforest	54	Moisture-dominated	-0.117	0.266	-0.679	0.000	0.172
Temperate grassland	752	Temperature-dominated	0.282	0.000	-0.120	0.001	2.344
Shrubland	54	Moisture-dominated	0.244	0.059	-0.354	0.007	0.691
Woodland	26	Jointly controlled	0.485	0.028	0.604	0.008	0.803
Savanna	97	Temperature-dominated	-0.321	0.002	0.032	0.746	10.071
Tropical seasonal forest	660	Moisture-dominated	0.072	0.068	-0.203	0.000	0.354
Tropical rainforest	76	Jointly controlled	-0.567	0.000	-0.306	0.001	1.852
Subtropical desert	26	Moisture-dominated	-0.051	0.761	0.760	0.000	0.067
Desert	62	No clear dominant control	0.262	0.096	0.001	0.997	498.747
Alpine	233	Temperature-dominated	0.293	0.000	-0.113	0.083	2.597
Agriculture	1808	Temperature-dominated	0.189	0.000	-0.030	0.191	6.230
Urban	16	No clear dominant control	0.632	0.218	0.781	0.134	0.810
Bare	21	Moisture-dominated	0.301	0.142	-0.537	0.013	0.560

Supplementary code 1 (CH_4)

The purpose of this script is to convert DOY-based daily CH_4 flux time series into monthly means (m1–m12), use the flux-unit information provided in "Studies and Fluxes-unit.xlsx" to compute unit-converted monthly/seasonal/annual flux values and generate a standardized Final17 table (Jan–Dec, four seasons and Annual), and finally paste the Final17 results back into "Studies and Fluxes.xlsx" in place by matching (Paper_number, Study_number) while preserving the target file's original row order.

Supplementary code 2 (soil moisture)

The purpose of this script is to standardize soil moisture (sm) records to WFPS (%) using template-derived soil physical parameters (ρb, φ, ρs) and sm units, aggregate DOY-based series to monthly means (sm1–sm12), then rescale the WFPS values so that the row maximum is capped at 100, while proportionally adjusting all other values in the same row., and finally paste the monthly means back into "Studies and Fluxes.xlsx".

Supplementary code 3 (soil temperature)

The purpose of this script is to compute monthly means (st1–st12) from DOY-based daily soil temperature observations in "CH4 uptake data_CH4 FLUX_1_1410.xlsx", and then paste the main-row monthly means into "Studies and Fluxes.xlsx".