Supporting Information

Magnitude and drivers of potential methane oxidation and production across Tibetan alpine permafrost region

Qiwen Zhang[1, 2], Guibiao Yang[1, 2], Yutong Song[1, 2], Dan Kou[1, 2], Guanqin Wang[1, 2], Dianye Zhang[1, 2], Shuqi Qin[1, 2], Chao Mao[1, 2], Xuehui Feng[1, 2], and Yuanhe Yang[1, 2*]

1. State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China
2. University of Chinese Academy of Sciences, Beijing 100049, China

***Corresponding author:** Dr. Yuanhe Yang, tel.: + 86 10-62836638, fax: + 86 10-62836632, E-mail: yhyang@ibcas.ac.cn

Number of pages: 14; Number of figures: 6; Number of tables: 5.

Table S1. Results of stepwise regression models testing the effects of the explanatory variables on CH_4 oxidation (Model 1) and production potential (Model 2). Statistics (*F* and *P* value) for the models are shown.

	Model 1				Model 2		
Model parameters	df	*F* value	*P* value	Model parameters	df	*F* value	*P* value
pmoA gene abundance	1	3.08	0.004	*mcrA* gene abundance	1	7.93	0.000
Soil moisture content	1	2.62	0.013	SOC	1	2.78	0.024
Residual	37			Residual	8		
AICc	-194.61			AICc	-26.92		

SOC, soil organic carbon content; AICc, corrected Akaike's information criterion.

Table S2. Comparison of the model performance and uncertainty assessment between linear regression analysis and support vector machine.

		Linear regression analysis	Support vector machine
Model performance based on 'Leave-one-out' cross-validation method	*r*	0.57	0.57
	RMSE	0.09	0.09
Uncertainty assessment with Monte Carlo approach (Tg year^{-1})	AS	6.5 [5.5, 7.7]	6.8 [5.9, 7.9]
	AM	4.0 [3.4, 4.7]	4.1 [3.6, 4.8]

Predicted mean value and the 95% confidence interval (values in square brackets) are shown in the table above. AS, alpine steppe; AM, alpine meadow.

Table S3. Comparison of cross validation results of three different Kriging methods combining with eleven semivariogram functions for two soil parameters (soil moisture content and *pmoA* gene abundance).

Parameters	Kriging methods	Simple		Ordinary		Universal	
	Semivariogram functions	R^2	*RMSE*	R^2	*RMSE*	R^2	*RMSE*
Soil moisture content	Circular	0.5208	7.0453	0.5148	7.0661	0.3621	8.1524
	Spherical	0.5232	7.0267	0.5221	7.0404	0.3627	8.1496
	Tetraspherical	0.5227	7.0289	0.5238	7.0268	0.3629	8.1487
	Pentaspherical	0.5205	7.0447	0.5247	7.0212	0.3626	8.1487
	Exponential	0.2380	8.9305	0.5185	7.0799	0.3675	8.1138
	Gaussian	0.5444	6.8695	0.5350	6.9425	0.3609	8.1709
	Rational Quadratic	0.2033	9.1747	0.5407	6.9021	0.3704	8.0939
	Hole Effect	0.5340	6.9459	0.5171	7.0814	0.3517	8.2314
	K-Bessel	0.5466	6.8519	0.5349	6.9427	0.3615	8.1680
	J-Bessel	0.5464	6.8520	0.5164	7.0874	0.3340	8.3893
	Stable	0.5444	6.8695	0.5350	6.9425	0.3609	8.1709
pmoA gene abundance	Circular	0.3142	0.4263	0.2560	0.4442	0.2558	0.4442
	Spherical	0.3144	0.4266	0.2548	0.4445	0.2546	0.4446
	Tetraspherical	0.3142	0.4269	0.2541	0.4447	0.2539	0.4448
	Pentaspherical	0.3138	0.4272	0.2537	0.4449	0.2535	0.4449
	Exponential	0.3163	0.4261	0.2509	0.4463	0.2509	0.4462
	Gaussian	0.3069	0.4282	0.2549	0.4447	0.2548	0.4447
	Rational Quadratic	0.3169	0.4259	0.2543	0.4449	0.2542	0.4449
	Hole Effect	0.3045	0.4333	0.2599	0.4426	0.2585	0.4430
	K-Bessel	0.3167	0.4253	0.2545	0.4448	0.2544	0.4448
	J-Bessel	0.3122	0.4277	0.2601	0.4425	0.2599	0.4426
	Stable	0.3155	0.4256	0.2549	0.4447	0.2548	0.4447

Table S4. Estimated potential methane (CH_4) fluxes across the Tibetan alpine grasslands.

Grassland types	Area (10^4 km^2)	Median value of potential CH_4 fluxes (ng g^{-1} dry soil h^{-1})	Mean value of potential CH_4 fluxes (ng g^{-1} dry soil h^{-1})	Total potential CH_4 fluxes (Tg $year^{-1}$)
Alpine steppe	64.0	-8.9	-8.9	-6.8
Alpine meadow	45.3	-9.4	-9.4	-4.1
Swamp meadow	5.1	11.8	11.8	0.6

Potential CH_4 oxidation fluxes (shown as negative value) in alpine steppe and meadow were estimated with SVM, and potential CH_4 production fluxes (shown as positive value) in swamp meadow was estimated with bootstrap method. The area of each grassland type was derived from a vegetation map of China (Editorial Committee for Vegetation Map of China, 2001). Reproduced with permission from ref 3. Copyright 2001 Science Press.

Table S5. Relevant information and the references included in the data synthesis targeting on the relationship between in situ methane (CH_4) emission rates and soil organic carbon content (SOC, 0-30 cm depth) in alpine wetlands on the Tibetan Plateau.

Literature source	Latitude (°N)	Longitude (°E)	CH_4 emission rates (mg m^{-2} h^{-1})	SOC (g kg^{-1})
Li et al. 2011	33.5	102.7	10.9	199.0
Li et al. 2011	33.5	102.7	21.4	250.4
Deng et al. 2013	33.1	102.6	29.2	390.4
Deng et al. 2013	33.1	102.6	27.1	331.4
Zhou et al. 2016	33.9	102.8	40.3	210.4
Zhou et al. 2016	33.9	102.8	3.7	143.2
Zhou et al. 2016	33.9	102.8	0.6	151.7
Yao 2007	33.9	102.9	0.5	134.1
Yao 2007	33.9	102.9	0.5	46.7
Ma et al. 2014	34.7	102.3	0.4	254.5
Ma et al. 2014	34.7	102.3	0.6	143.8
Ma et al. 2014	34.7	102.3	0.2	86.8
Zhou et al. 2017	33.9	102.8	7.7	191.6
Wang et al. 2009	34.7	92.9	0.5	47.4
Wang et al. 2009	34.7	92.9	0.2	41.3
Wang et al. 2009	34.7	92.9	0.1	37.1
Cui et al. 2017	33.9	102.8	2.8	151.4

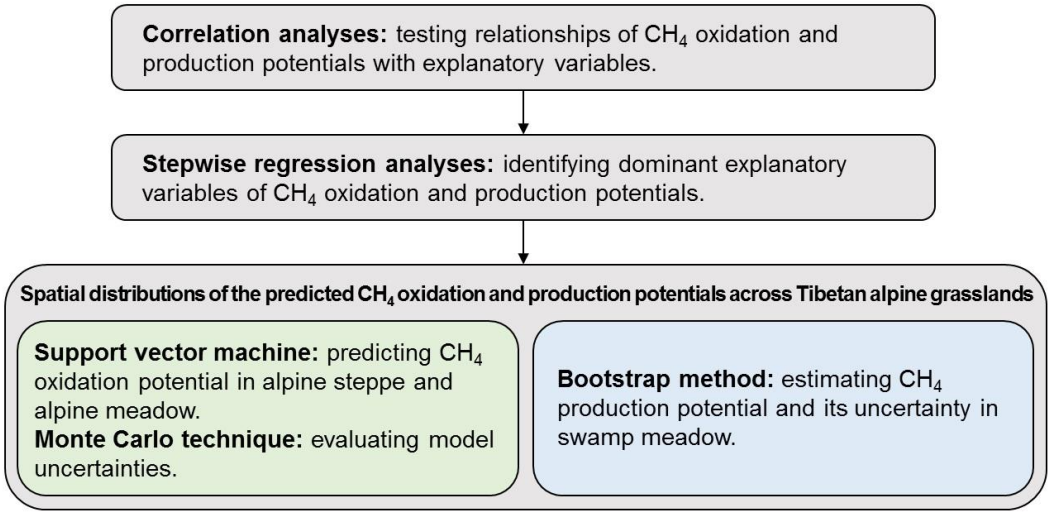

Figure S1. Flow chart of statistical analyses used in this study.

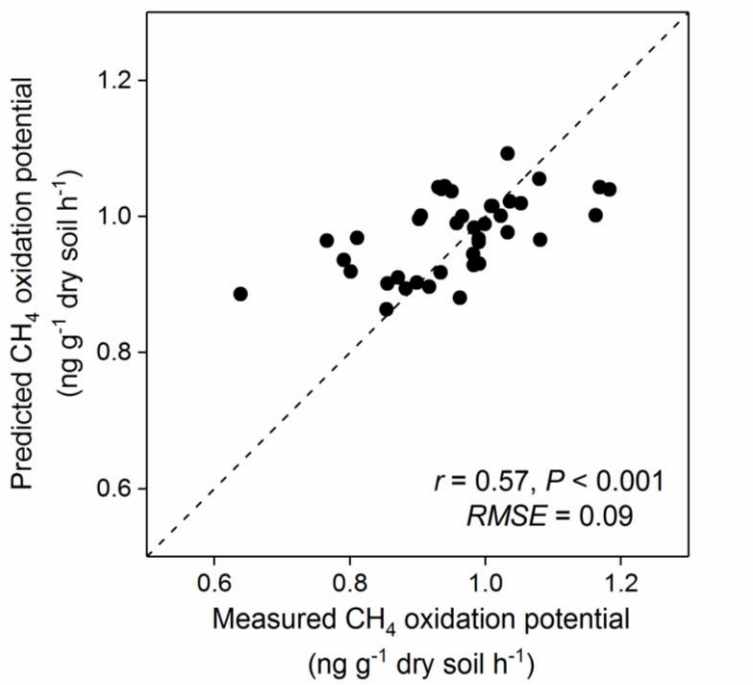

Figure S2. "Leave-one-out" cross-validation for the multivariable linear regression model used for predictions of methane (CH_4) oxidation potential.

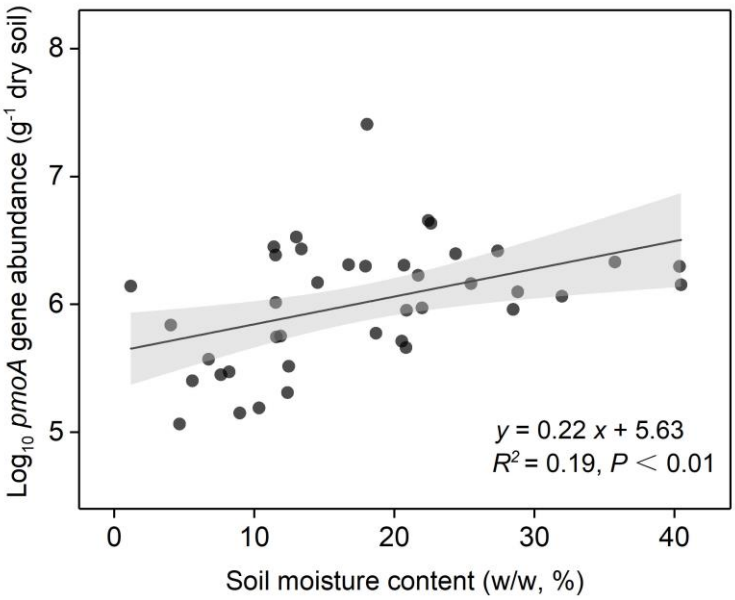

Figure S3. Relationship between *pmoA* gene abundance (log_{10} g^{-1} dry soil) and soil moisture content (w/w, %) in Tibetan alpine steppe and meadow (data from our experiment). The solid line and shade represent the regression line with 95% confidence interval. Statistics (R^2 and *P* value) for the linear regression are shown.

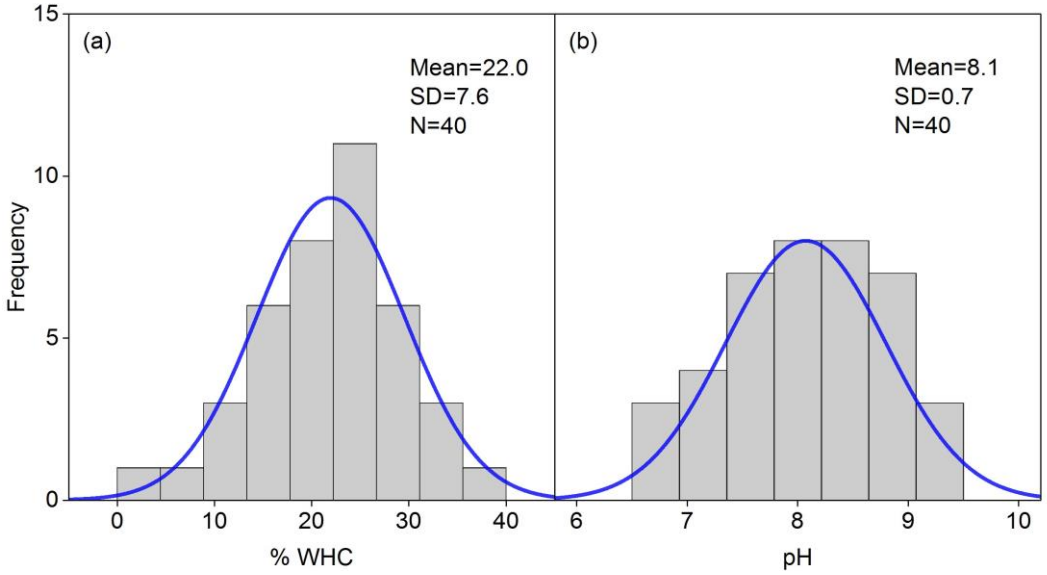

Figure S4. Frequency distribution of water-holding capacity (a) and pH (b) in alpine steppe and meadow on the Tibetan Plateau (data from our experiment).

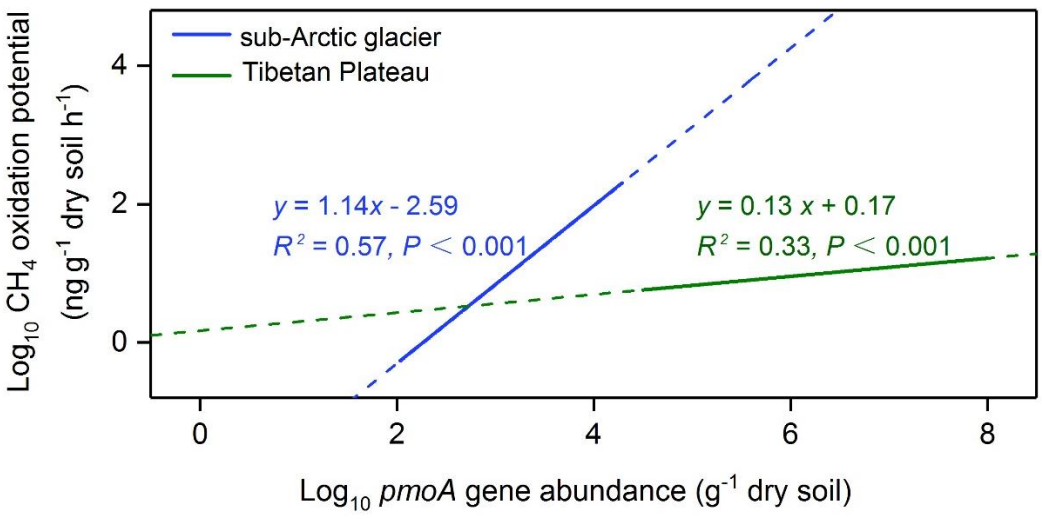

Figure S5. Relationship between methane (CH_4) oxidation potential (log_{10} ng g^{-1} dry soil h^{-1}) and *pmoA* gene abundance (log_{10} g^{-1} dry soil; 0-10 cm depth) in the sub-Arctic glacier (data from Mateos-Rivera et al., 2018) and the Tibetan Plateau (data from our experiment). Statistics (R^2 and P value) for the linear regression are shown.

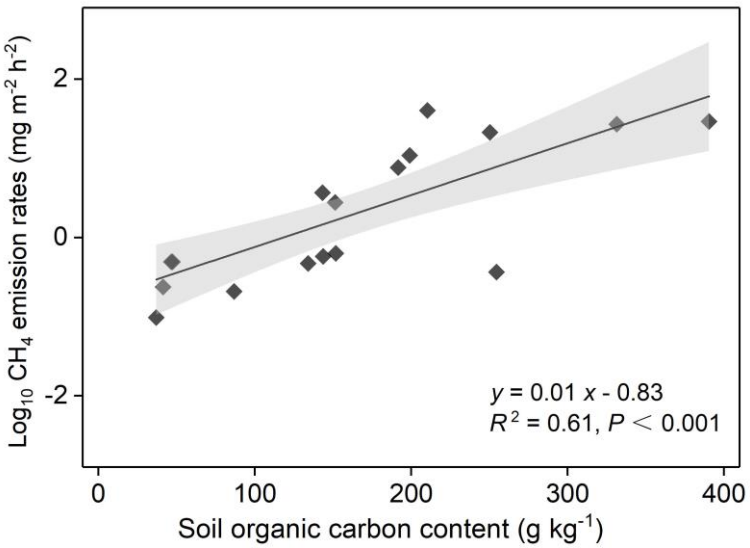

Figure S6. Relationship between in situ methane (CH_4) emission rates (log_{10} mg m^{-2} h^{-2}) and soil organic carbon content (g kg^{-1}; 0-30 cm depth) in swamp meadow and alpine wetland on the Tibetan Plateau (data from Table S5). The black line and shade represent the regression line with 95% confidence interval. Statistics (R^2 and P value) for the linear regression are shown.

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