Supplementary materials for manuscript entitled: Impacts of climate and reclamation on temporal variations in CH_4 emissions from different wetlands in China: From 1950 to 2010.

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Supplementary material S1: Estimate CH_4 emissions from lakes and rivers

In this paper, we totally followed Chen's method (Chen et al., 2013) to calculate regional CH_4 emissions from lakes and rivers across China. Lakes can be found in five major regions in China: the plains of eastern China, the Qinghai-Tibetan Plateau, the Yunnan-Guizhou Plateau, the Mongolia-Xinjiang Plateau, and the Northeast China Plain (Wang and Dou, 1998). The followed equation was used to calculate regional CH_4 emissions from lakes:

$$CH4_{regional} = \sum_i \sum_j \sum_k f_{ijk} \times A_{ijk} \times D_{ijk} \quad \text{(S1.1)}$$

Where i is the lake region, j is the growing season and non-growing season (between the different regions), and k is the different zones (pelagic zone and/or littoral zone). f_{ijk} is the seasonal mean CH_4 fluxes under conditions of i, j, and k (listed in Table S1). A_{ijk} is the lakes' area, and D_{ijk} is the duration of the growing and non-growing season or the unfrozen season. $CH4_{regional}$ is the regional CH_4 emissions from lakes.

The average area-weighted CH_4 flux was calculated as followed:

$$CH4_{flux} = \frac{CH4_{regional}}{\sum_i \sum_j \sum_k A_{ijk}} \quad \text{(S1.2)}$$

Uncertainties of the estimation were come from the fraction of the littoral zones of the lakes, which was assumed at 5% to 12% for all lakes in China based on a preliminary estimate (Chen et al., 2009). More details about this method please see Chen et al. (2013).

When used [Eqn. (S1.1)] to calculate regional CH_4 emissions from rivers, f_{ijk} is assumed to equal to the value in the pelagic zone, since no available data present.

Table S1 Measurements of CH_4 fluxes from lakes in China, from Chen et al. (2013).

Location	Zones	CH_4 flux (mg m^{-2} h^{-1})	Sampling season	References
		Eastern Plain		
Lake Donghu	Pelagic zone	0.97±0.78	Apr. 2003 to Mar. 2004	Xing et al., 2005
Lake Taihu	Littoral zone[a]	0.4±0.9	Aug. 2003 to Aug.2004	Wang et al., 2006
	Littoral zone[b]	10±23.0	Aug. 2003 to Aug.2004	
	Pelagic zone	0.5 ±1.9	Aug. 2003 to Aug.2004	
Lake Boyang	Pelagic zone	0.82±0.22	Dec. 2004 to Jan.2005	Chen et al., 2007
Lake Dongting	Pelagic zone	0.2±0.64	Dec. 2004 to Jan.2005	Chen et al., 2007
Lake Caohu	Pelagic zone	0.021 ±0.012	Dec. 2004 to Jan.2005	Chen et al., 2007
Lake Nansihu	Pelagic zone	0.034 ±0.020	Dec. 2004 to Jan.2005	Chen et al., 2007
Lake Hongzehu	Pelagic zone	0.019 ±0.010	Dec. 2004 to Jan.2005	Chen et al., 2007
Three Gorges Reservoir Region	Littoral zone	6.7 ±13.3	Jul. to Sep.,2008	Chen et al., 2009a
	Pelagic zone	0.26 ±0.38	Jan. to Dec., 2009	Chen et al., 2011
	Littoral zone	0.22 ±0.26	the inundated season	Yang et al., 2012
		Qinghai-Tibet Plateau		
Lake Huahu	Littoral zone	15.1	Jun. to Aug. 2006 and 2007	Chen et al., 2009b
		Mongolia-Xinjiang Plateau		
Lake Wuliangsu	Littoral zone[b]	15.28	Apr. to Oct.2003	Duan et al., 2005
	Littoral zone[c]	2.16	Apr. to Oct.2003	
		Yunnan-Guizhou Plateau		
Lake Fuxianhu	Pelagic zone	0.012 ±0.029	Dec. 2004 to Jan.2005	Chen et al., 2007
Lake Erhai	Pelagic zone	0.044 ±0.15	Dec. 2004 to Jan.2005	Chen et al., 2007
Lake Dianchi	Pelagic zone	0.16±0.035	Dec. 2004 to Jan.2005	Chen et al., 2007
		Taiwan Island		
10 lakes on plateau	Pelagic zone	0.07 ±0.06	NS	Wang et al., 1998
26 lakes on plain	Pelagic zone	0.11 ±0.19	NS	Wang et al., 1998

[a] Bare littoral zone; [b]Emergent plant zone; [c]Submerged plant zone; NS, not specified.

Supplementary material S2: Model description, modification and validation

S2.1 Modification to $CH4MOD_{wetland}$

In $CH4MOD_{wetland}$, the environmental factors that influence CH_4 production and emission in natural wetlands include soil temperature, soil texture and soil redox potential. Previous studies (Atkinson and Hall, 1976; King and Wiebe, 1978; Bartlett et al., 1985; 1987; Magenheimer et al., 1996) indicate that methane emissions from various coastal salt marshes in the temperate zones vary with salinity. In order to provide the capability of simulating methane emissions from coastal wetland, we adopted the relationship between salinity and methane fluxes according to Poffenbarger et al. (2011).

$$f(s) = 10^{a \times s} \quad \text{(S2.1)}$$

where *f(s)* represents the effect of salinity on CH_4 production. *s* is the salinity (psu, practical salinity unit). *a* is an empirical constant.

S2.2 Description of TOPMODEL for simulating water table depth

Following previous research (Bohn et al., 2007; Kleinen et al., 2012; Lu and Zhuang et al., 2012; Zhu et al., 2013), this study is based on the topographic wetness index (TWI) $ki = \ln(\alpha_i / \tan\beta_i)$ to represent the spatially distributed water table depth for a 1 km sub-grid within a grid of 0.5°, where α_i is the upslope contributing area above point *i*, $\tan\beta_i$ is the local surface slope at that point. The central equation of TOPMODEL is

$$zi = z - m \times (ki - \lambda) \quad \text{(S2.2)}$$

where *zi* is the local water table depth in a 1 km pixel, *z* is the average water table depth in the 0.5° grid, *m* is the scaling parameter, *ki* is the local topographic wetness index (TWI) in the 1 km pixel, λ is the average of *ki* over the 0.5° grid cell. The value of *z* is calculated by the soil moisture content in a 0.5° grid cell. More details about calculating the average water table depth please see the previous study (Letts, et al., 2000; Lu and Zhuang et al., 2012). For the scaling parameter *m*, Kleinen et al. (2012) described it as the capability of transmissivity with depth. In previous study (Bohn et al., 2007), this parameter was calibrated using the observed water table depth. In this study, we used the observed water table depth at SJ, REG, WLS and LRD (Table S2) to calibrate the scaling parameter *m* at each site. When extrapolating to large regions, the value of *m* at SJ, REG, and WLS (Table S3) were assigned to Region I, Region II and Region III, respectively. In Region IV, we used the parameters for WLS because of the similar wetland types (Table S2). The value for REG (Table S3) were allocated to Region V because this wetland is located at the edge of this region. The value for the coastal wetland parameters were assigned based on LRD (Table S3).

After acquiring the local water table depth (zi) for each 1 km pixel, we used an approach of (Zhu et al., 2013). The water table depth z_{wet} of wetland in a 0.5° grid cell is calculated as

$$z_{wet} = \frac{\sum_{i=1}^{i=n} z_i}{n} \quad \text{(S2.3)}$$

where n is the number of 1 km wetland pixels within each 0.5° grid cell, and the value of n is derived from the GLWD-3 data set, within each grid cell.

S2.3 Model validation

Two simulations were made to test the model performance at the site scale and the grid scale. To begin with, we used the site-specific measurements of air temperature, soil temperature, water table depth, aboveground net primary productivity (ANPP) and the observed plant phenology to drive $CH4MOD_{wetland}$ to simulate site-specific daily CH_4 fluxes at each site (Table S2). We compared these daily simulated CH_4 fluxes with the measurements. Fig S1 (a, b, d, e, g, i and k) and Fig S2a shows the comparisons of the seasonal variations and the monthly amount between the modeled and observed CH_4 fluxes.

Moreover, in order to test the performance of the integrated model framework ($CH4MOD_{wetland}$/TEM/TOPMODEL) (Fig. 1) at the grid level, we also compared the observed monthly CH_4 fluxes in the wetland sites (Table S2) and the simulated monthly CH_4 fluxes at the 0.5°×0.5° grid. We used the gridded data of climate, soil and vegetation to drive the integrated model framework (Fig. 1) on a monthly step. Field measurements in the wetland show that there are large uncertainties in the ANPP, standing water depth and the plant phenology. For example, in the Sanjiang Plain, the range of ANPP ranges from 422 to 530 g m^{-2} (Hao, 2006; Li et al., 2012); The average standing water depth during the growing season ranges from 1 to 10 cm (Song et al., 2007); The mature period of the plant ranges from mid-July to mid-August (Hao, 2006). We made 8 sensitivity experiments with differing ANPP, standing water depth and the plant mature period. The range of input ANPP, standing water depth and the plant mature period are from the observed data at each wetland sites (Table S3). Variations of half the range in ANPP, standing water depth and the plant mature period on the basis input data were used as the maximum and minimum values of the input. Error bars in Fig. S1 (c, f, h, j, l) and Fig. S2b are determined by the sensitivity experiments.

Table S2 Site description

Site name	Location	Wetland type	Plant speices	Experiment period	References
Sanjiang Plain (SJ)	47°35′ N,133°31′E	marsh	*Carex* and *Deyeuxia*	2003-2005	Hao (2006); Song et al., (2007)
Ruoergai Plateau (REG)	32°47′N,102°32′E	peatland	*Carex*	2001	Ding et al., (2004)
Haibei alpine marsh (HB)	37°29′N,101°12′E	marsh	*Carex*	2002	Hirota et al., (2004)
Zhalong wetland (ZL)	46°52′N -47°32′N, 123°47′E- 124°37′E	floodplain	*Phragmites*	2009	Huang et al., (2011)
Wuliangsu lake (WLS)	40°47′ -41°03′ N, 108°43′-108°57′ E	floodplain	*Phragmites*	2003	Duan et al., (2005)
Liao river delta (LRD)	40°40′-41°25′N, 121°35′- 122°55′E	coastal wetland	*Phragmites*	1997	Huang et al., (2005)
Chonging island (CMI)	31°00′ -31°30′ N, 121°00′ -122°00′ E	coastal wetland	*Scirpus*	2004	Yang et al., (2007)

Table S3 Site-specific parameters and model inputs of $CH4MOD_{wetland}$ and TOPMODEL

Parameters and inputs	Description	Value							Unit
		SJ	REG	HB	ZL	WLS	LRD	CMI	
VI*	Vegetation index	2.4[a)1], 2.8[b)1]	2.4[1]	2.4[1]	1[1]	1[1]	1[1]	1[1]	dimensionless
ANPP^	Above-ground net primary productivity	485[a)2], 450[b)2]	340[c)3], 290[d)3]	380[4]	1200[5]	1860[e)6], 2520[f)6]	1200[5]	692[7]	$g\ m^{-2}\ yr^{-1}$
f_{root}*	Proportion of below-ground to the total production	0.6 [a)8], 0.5 [b)8]	0.6 [c)d)9]	0.5[9]	0.5[9]	0.5[9]	0.5[9]	0.5[9]	dimensionless
P_{ox}*	The fraction of CH_4 oxidized during plant mediated transport	0.5[1]	0.5[1]	0.5[1]	0.9[1]	0.9[1]	0.9[1]	0.9[1]	dimensionless
T_{veg}*	The fraction of plant mediated transport was available	1[14]	1[14]	1[14]	1[14]	1[14]	1[14]	1[14]	dimensionless
SAND^	Soil sand fraction	56.0[a)10,11] ,47.0[b) 10,11]	66.0[10,11]	80[12]	47[12]	80[12]	30[12]	65[12]	%
SOM^	Concentration of soil organic matter	70[a) 10,11] ,246[b) 10,11]	520[10,11]	146[13]	222[13]	133[13]	103[13]	212[13]	$g\ kg^{-1}$
ρ ^	Soil bulk density	1.00[a) 10,11] ,0.74[b) 10,11]	0.75[10,11]	1.73[13]	1.40[13]	1.52[13]	0.9[13]	1.55[13]	$g\ cm^{-3}$
m*	Scaling parameter in TOPMODEL	1.0[1]	0.8[1]	0.8[1]	1.0[1]	0.8[1]	1.6[1]	1.6[1]	dimensionless

a) For *Carex lasiocarpa* site; b) For *Deyeuxia angustifolia* site; c) For *Carex meyeriana* site; d) For *Carex muliensis* site; e) For *Phragmites australis* site1; f) For *Phragmites australis* site2; * Defined as model parameters; ^ Defined as model inputs.

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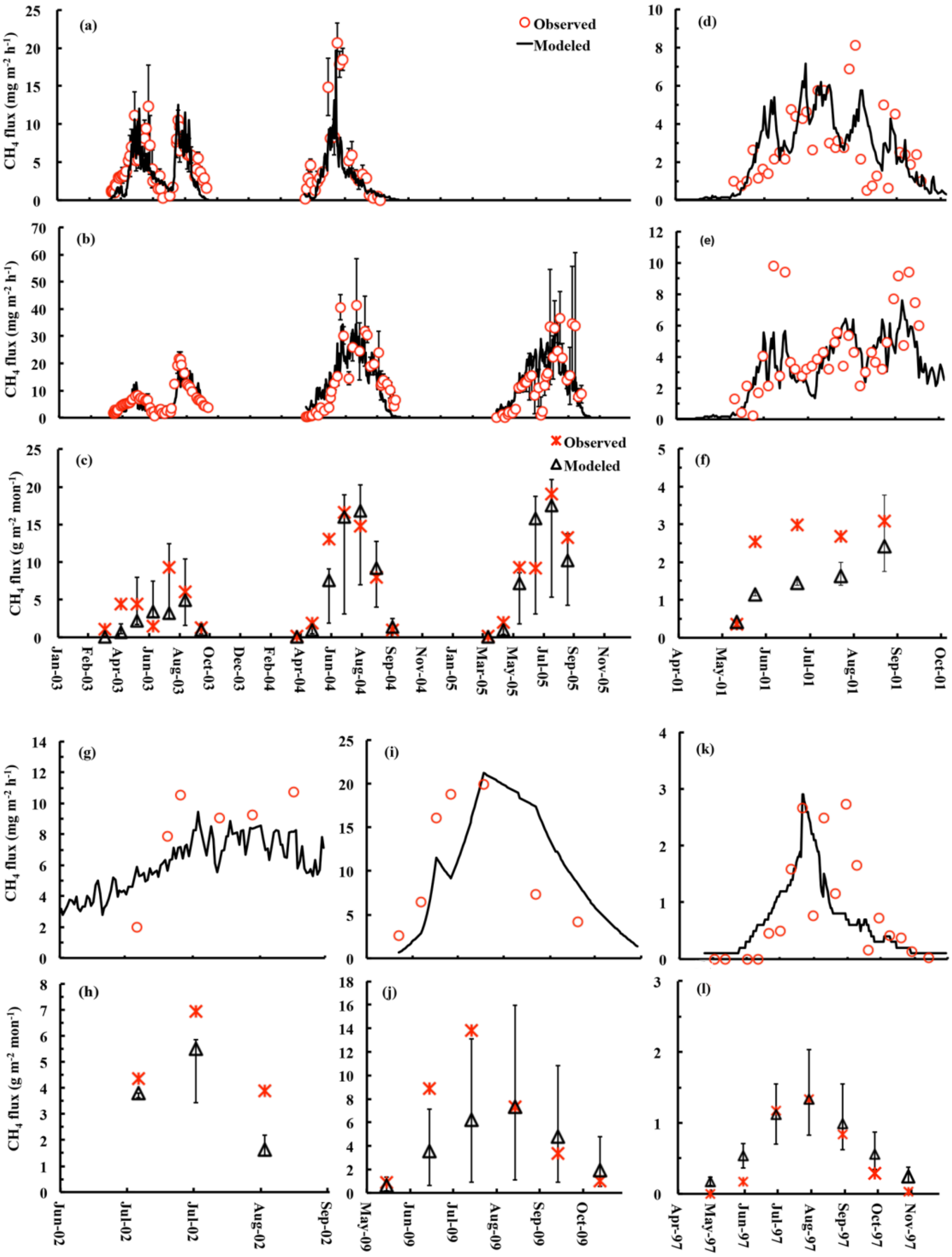

Fig. S1: Comparison of simulated and observed seasonal CH_4 variations. SJ: the “site-scale” validation (a, b), the “grid-scale” validation (c); REG: the “site-scale” validation (d, e), the “grid-scale” validation (f); HB: the “site-scale” validation (g), the “grid-scale” validation (h); ZL: the “site-scale” validation (i), the “grid-scale” validation (j); LRD: the “site-scale” validation (k), the “grid-scale” validation (l). Error bars in a and b are the standard errors from 3 sampling replicates. Error bars in c, f, h, j and l are the uncertainties from the heterogeneities of ANPP, standing water depth and the plant mature period in the grid.

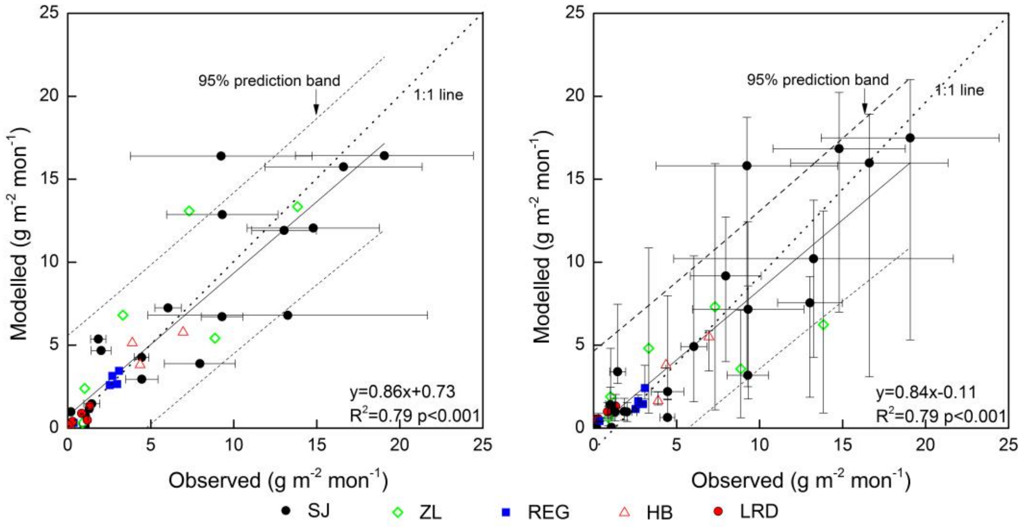

Fig. S2: Observed vs. simulated monthly CH_4 emissions from 5 wetland sites. (a) site-scale validation; (b) grid-scale validation. Dashed line is 1:1. The horizontal bars represent standard errors from 3 sampling replicates in SJ. The vertical bars are the uncertainties from the heterogeneities of ANPP, standing water depth and the plant mature period in the grid. For the wetland where two micro-sites locate (SJ and REG), the average observed/simulated values were used to represent the average CH_4 emissions at that site.

Supplementary material S3: Division of the inland wetlands in China

Chinese inland wetlands are divided to 5 regions (Fig. 2) (Lang and Zu, 1983). They are distributed unevenly and primarily occur in northeastern China (30%) (Region I; Fig. 2) and the Qinghai Tibetan Plateau (50%) (Region II; Fig. 2) (Ding et al., 2004). Marshes (dominated by *Carex*, *Phragmites*, *Cyperus*, *Blymus*, and *Deyeuxia*) and the swamps (dominated by *Alnus* and *Larix*) are widely distributed in the northeast China. Peatlands (dominated by *Carex*, *Pedicularis*, and *Scirpus* species) are the mainly type in Qinghai Tibetan Plateau. In Region III (Fig. 2) (Inner Mongolia and northwestern China) and Region IV (Fig. 2) (North China plain and the Middle-Lower Yangtze Plain), marshes and floodplains dominated by *Phragmites australis* are the important landscape. Peatlands (dominated by *Carex and Sphagnum*) and marshes (dominated by *Phragmites australis*) are the main types in Region V (Fig. 2) (southern China).

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