Institute of Atmospheric Physics

Chinese Academy of Sciences

September 20, 2015

Dear Dr Román-Cuesta：

The manuscript (bg-2015-154) entitled "**Impacts of climate and reclamation on temporal variations in CH_4 emissions from different wetlands in China: From 1950 to 2010**" by Tingting Li, Wen Zhang, Qing Zhang, Yanyu Lu, Guocheng Wang, Zhenguo Niu, Maarit Raivonen and Timo Vesala has been revised according to the comments from the editor and the reviewers. We are very grateful for your helpful comments.

In the revised manuscript, we modified the INTRODUCTION and reshaped the DISCUSSION according to your suggestion. In response to the suggestion from the reviewers, we added a brief description of $CH4MOD_{wetland}$ with sufficient details in SECTION 2.1. In addition, we discussed the present state as well as the research gaps concerning the regional modeling of CH_4 emission from wetlands in SECTION 4.4. For your guidance, the itemized responses to the comments from reviewers and the editor are appended to the end of this letter. In addition, the major changes made in the revision were highlighted in the revised manuscript.

Thank you for your suggestions and detailed instructions for the revision of the MS. Correspondence regarding the MS should be directed to W. Zhang using the following address, phone number, or e-mail address:

Address: Institute of Atmospheric Physics, CAS. No.3, Huayanli, Chaoyang District, Beijing, 100029, China

Tel: 86-10-62071389

Fax: 86-10-62071389

E-mail: zhw@mail.iap.ac.cn

Yours sincerely，

Wen Zhang

Editor：General

Bibliography needs improving: Update references and when possible chose peer-reviewed journals over other non-peer-reviewed sources (e.g. Davidson 2014, versus bulletins, or proceedings). There are useful references for your research that are not cited (Ringeval et al. 2010, Montzka et al. 2010, Melton et al. 2013, Wania et al. 2013, Davidson 2014, Tian et al. 2015)

Please summarize and select core information exposed in the entire manuscript. Expose it in a coherent way that allows readers follow up our text easily. Subdivide the information into sections.

Response: We have updated the references and used peer-reviewed journals as far as possible. We also cited the references according to your suggestion:

Ringeval et al. 2010 in section 4.4, page 22, line 23.

Montzka et al. 2010 in section 1, page 2, line 26.

Melton et al. 2013 in section 4.4, page 22, line 26.

Wania et al. 2013 in section 4.4, page 22, line 17.

Davidson 2014 in section 1, page 2, line 32.

Tian et al. 2015 in section 4.4, page 21, line 7.

The entire manuscript was totally reshaped according to your helpful suggestions. The detailed modifications are listed in the followed response.

INTRODUCTION

Your introduction can be improved by clearly exposing what is the importance of your research (both for China and for the region, but also for the atmospheric contribution to the world---how much does Chinese emissions represent in the regional and global budget?, what are the uncertainties?), what is known about your research topic in China, what are the current limitations and gap knowledge on long term assessments of CH4, how do you propose to advance the current scientific knowledge with your research (how is your research different to what has already been done?). Could we have some information on the scale of wetland emissions in China compared to paddy rice emissions, are we talking about a large flux? Please put your research into a CH4 national context.

Response: The introduction was modified thoroughly according to your suggestion. The change was highlighted in the manuscript.

We agree with the editor that the importance of the research should be exposed in the introduction. In the revised introduction, we pointed that China has the world's fourth largest wetland area. In addition, Chinese wetlands consists consist of a wide variety of types and are representative in the world (page 3, lines 3-4). Although Chinese wetlands emit 1.7–10.5 Tg CH_4 yr^{-1} (page 3, line 26), which only accounts for less than 5% of the global emissions (page 2, line 29), it is non-negligible on a national scale (We added a paragraph to expose that on a national scale, although CH_4 emissions from natural wetland is less than the rice paddies, it is comparable with other sources such as the coal-bed emissions, residential biofuel combustion, landfill emissions and biomass burning. Please see page 16, lines 20-33; page 17, lines 1-2). So we are talking about a source that could not be neglected.

Moreover, this study mostly focused on the influence of climate and human activities of the national CH_4 emissions. The decrease of CH_4 emissions induced by the wetland reclamation was frequently ignored when estimating the national CH_4 emission trends. So this study is important to understand the CH_4 budget and trends of China as well as the contribution to the world (page 3, lines 12-18 in the revised MS).

Little research on long-term CH_4 assessments was found in China. We introduced the related research in China and pointed the research gap in page 3, lines 19-34 and page 4, lines 1-4 in the revised MS.

Please clarify the definition of wetland in the introduction and abstract (which wetlands are included?, why?, are paddy rice areas included?) One can argue that river and lakes (inland waters) CH4 emissions have particular CH4 dynamics, different than wetlands (e.g. supersaturation processes through soluble carbon and complex drainage systems (Borges et al. 2015, Raymond et al. 2013). Eventhough you separate their estimates through different methods, merging inland waters to wetlands brings certain level of confusion/ complexity (methodological and argumental). Please justify why you have chosen to merge these categories of land and water classes.

Response: This study is focused on the natural wetlands and doesn't contain the rice paddies. The definition of the natural wetland in this study includes coastal wetlands, lakes and rivers, and other types (e.g., marshes, swamps, peatlands, and floodplains) that are defined as inland wetlands. The definition of the wetland was in the abstract (page 1, lines 26-27 in the revised MS) and the introduction (page 4 lines 6-7 in the revised MS).

The reasons of including lakes and rivers are: At first, both the Ramsar Convention (Ramsar, Iran, 1971) and the Chinese government (An et al., 2007) defined that the natural wetlands included a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas (we explained this in page 4, lines 19-24 in the revised MS). So lakes and rivers are part of the natural wetlands and should not be excluded from the natural wetlands. Secondly, Besides inland marshes/swamps, lakes, rivers and coastal wetlands are also important to the national CH_4 budget (Bastviken et al., 2004; Yang et al., 2011; Chen et al., 2013), and also suffered significant reclamation during the past 60 years (An et al., 2007) (we explained this in page 3, lines 33-34, page 4, lines 1-2). A comprehensive assessment focus on the influence of wetland conversion and climate on national CH_4 emissions should not exclude lakes and rivers.

Please eliminate confusing sentences:

While the majority of CH4 sinks remain relatively stable, variations in atmospheric CH4 have been attributed to these sources.

A remote sensing study presented a comprehensive map of the change in natural wetlands that occurred between 1978 and 2008 in China (Niu et al., 2012).

Goal: The objectives of the present study are to analyze the spatial and temporal changes in CH4 emissions across China's natural wetlands to quantify the impact of climate change and anthropogenic activities on CH4 emissions from the natural wetlands in different regions of China

Response: These confusing sentences have been clarified or replaced.

METHODS

Please reorganize the methods into subsections that separate:

1. Study area with a characterization of your regions (e.g. soils, temperature, precipitation, human pressures). Please include a clear definition of wetland types and justification of choice (some of it should have already been presented in the introduction)

Response: The soils, temperature, precipitation and human pressures of the regions are introduced in the revised Supplementary materials S3. The definition of the wetland types and the justification of choice were explained in the methods revised MS (page 4, lines 19-24).

2. Data sets (create subsections for each data set) with a clear description of the temporal thresholds of each data (eg. what happens with wetland area from 1950 to 1978?, climate data used goes from which year to which year?).

Response: We have reorganized subsections for the data sets of the CH_4 measurements, wetland area, climate, soil moisture, soil texture, plant, hydrology and the salinity (section 2.8 in the revised MS). We explicitly stated in the revised MS that the temporal thresholds of the climate, soil moisture, *ANPP* and salinity are from 1950 to 2010. We also clearly stated that detailed data of the wetland distribution are only available for the years 1950, 1978, 2000 and 2008 (page 11, lines 19-20). From 1950 to 1978, the wetland underwent decreasing all the time according to the historical census data. However, in this study, in order to avoid the uncertainties induced by the annual variation of the wetland area, the wetland methane emission were made only in 1950s, 1980s, 1990s, 2000s and 2010s to delineate the temporal trends.

3. Methods subdivided by inland waters (lakes and rivers) and by other wetland types. Lakes and rivers need a methodological explanation by its own, since they are extrapolated from existing data.

Response: We moved the methods to estimate CH_4 emissions from lakes and rivers from the supplementary material to section 2.6 (page 10).

4. Separate methods for wetland area estimates from CH_4 emissions.

Response: The methods for wetland area were separated and shown in section 2.7.

5. A brief, comprehensive description of what models are you using (and their modifications), their variables, and their known limitations, would be useful (please complement Figure 1 to make it more complete). Move discussion section of models to here (and summarize). Do not rely on supplementary to expose core functioning of your models and the impacts on the final estimates.

Response: According to your guidance, we modified the description of the model in section 2.1. The description of the model structure, variables, inputs and outputs are explained in page 5, from line 1 to line 21 in the revised MS. The limitations of the model were moved from the discussion to the methods, and summarized (please see page 5, lines 21-26). The modification of the model was moved from the supplementary material to the methods (page 6, lines 13-21). In addition, we completed Fig. 1 by adding the model modification, calibration and validation (page 43 in the revised MS).

6. Rethink and focus the model parameterization and calibration at national scales, right now it reads like the merging of not too well connected sentences. What is important to parametrize, calibrate, and extrapolate to national levels, what have you done, and what is missing. Right now it reads as a not too well connected, anecdotic sequence of sentences.

Response: We are very thankful to the editor's comments. But we must say that the model parameterization or calibration could only be made at a site scale, where the CH_4 measurements are available. No available data sets of the national CH_4 emissions could support the model calibration on a national scale. We can only calibrate the model as the site scale and then make validation to make sure that the model is capable to be up scaled to the national scale.

We modified description of the model calibration (section 2.2) and model up scaling (section 2.4) according to the editor's suggestion. The changes are highlighted in the revised MS.

7. Uncertainties: Estimating the extreme conditions exposes a measure of variability, but classical uncertainty methods use methods like Monte Carlo. Please expose better your uncertainty approach, and please explain how have you produced the Baseline estimates and the 8 simulations (what are these?)

Response: The extreme condition approach were widely used in estimating uncertainties of GHG from ecosystems (Li et al., 1996; 2004; Giltrap et al., 2010; Kesik et al., 2005), owing to it is less computationally expensive than the Monte Carlo method. Previous studies (Li et al., 2004) showed that the flux ranges produced by the extreme condition approach (the same as MSF method in his paper) accounted for 97, 98, and 61% of the fluxes produced by the Monte Carlo method for CO_2, CH_4, and N_2O from Chinese rice paddies. He also concluded that though the extreme condition approach gives no statistical information of the estimation uncertainty, it provides reliable information of the uncertainty ranges. We added the statements why we chose the extreme condition approach other than Monte Carlo in the revised MS (page 9, lines 14-23).

We also explained how to produce the baseline estimate and definition of the 8 extreme scenarios for uncertainty analysis in page 9, lines 24-34 in the revised MS.

8. Uncertainty in wetland CH_4 emissions has been reported to mainly depend on wetland area (Ringeval et al. 2010) but in your uncertainty analysis you do not consider area variation. Please justify.

Response: We agree with the editor that variation of the wetland area was an important cause of the uncertainty of regional and national CH_4 emissions. We added a paragraph to discuss this uncertainty induced by the wetland area in section 4.4 (page 22, lines 13-33, page 23, lines 1-9). The uncertainty caused by the inaccuracy of the wetland area is usually direct and simple (emission = flux * area) and can be easily interpreted when information of the wetland area is available. However, it's difficult to estimate the seasonal or annual variation of the wetland area due to limitation of the data availability. We therefore used the "Prescribed constant wetland extents" from the remote sensing data by Niu et al. (2012). In this study, we focused mainly on the uncertainty induced by fallacy in the modelling mechanism and the limited availability of the model inputs which are more complex and hard to be interpreted directly. We also think improving the model performance is one of the largest challenges that should be considered in future.

RESULTS

9. "In this section, we analyze the climate change-driven interannual variations in CH4 fluxes from the inland wetlands and the coastal wetlands from 1950 to 2010".-------what happens with the other categories (lakes, rivers)?

Response: In the first part of the "Results" section, we have explained that the CH_4 flux was the CH_4 emissions per area (section 3.1, page 12, line 23 in the revised MS). The CH_4 fluxes of the lakes and rivers are from the extrapolated measurements (please see section

2.6). Using this method, we can’t estimate the influence of climate change on the CH_4 fluxes.

10. Create subsections in the results where you separate the results of wetland decrease trends from CH_4 emissions

Response: We have separated the results of wetland decrease trends into an independent section (section 3.2, page 15, lines 8-24).

11. Tibetan Plateau, justify your results:

“On the Qinghai Tibetan Plateau (Region II), the simulated CH_4 fluxes exhibited the lowest fluxes (Fig. 3b), with an average annual mean of 6.2 gm^{-}2”

Against

Chen et al. 2013

“Natural wetland estimates were slightly higher than the other estimates owing to the higher CH4 emissions recorded within Qinghai-Tibetan Plateau peatlands.”

Response: Chen et al. (2013) were primarily based on measurements from Ruoergai at the eastern edge of Tibetan Plateau. However, the spatial characteristics show that Ruoergai has a higher CH_4 flux than the other places on the Qinghai Tibetan Plateau, e.g. Huashixia (5.3—6.7 g m^{-2} yr^{-1}) with an altitude of 4000 m in central Qinghai Tibet Plateau (Jin et al., 1999) and Namuco (0.6 g m^{-2} yr^{-1}) with an altitude between 4718 and 7111 m in the hinterland of Qinghai Tibetan Plateau (Wei et al., 2015), because it has the lower altitude and the continuous flooding (Chen et al., 2008; Hirota et al., 2004). So it may introduce large bias when extrapolating the measurements at the eastern edge of Tibetan Plateau to the whole plateau. The simulated average CH_4 flux from Qinghai Tibet Pleateau in 1990 by $CH4MOD_{wetland}$ is 6.2 g m^{-1} yr^{-1} (5.0—7.2 g m^{-2} yr^{-1}), which is close to the observation at Huashixia, between the observations from Namucuo and Ruoergai. This discussion was in section 4.1 (page 17, lines 18-28).

DISCUSSION

The discussion needs to enhance the importance of your results under a national level, a regional level and a global level. It should expose what are the new scientific achievements, what is still missing (research gaps), and possibly conclude with next steps and/or offer some management and conservation tips. Please consider when rewriting.

Response: We have reshaped the discussion thoroughly according to your guidance. In the revised MS, section 4.1 exposed the importance of the results (page 16, lines 21-33; page 17, lines 1-2). The present study involved all types of the wetlands in China and the up-to-date knowledge of the wetland methane emissions as well as the datasets of the model inputs and temporal changes in wetland area. And according to both the editor and the reviewer's guidance, we discussed the present research state and the research gaps in section 4.4 (pages 20-23). We also added discussion about the wetland managements and conservation tips in section 4.3 (page 20, lines 9-24).

12. Plants physiology is not linked to the research presented before. It should go out. Model and parameters should be summarized and go to methods (sections 4.1 and 4.2 are too general and not well connected to your research focus)

Response: We have moved the model parameters to the methods and moved the uncertainty induced by the water table depth to section 4.4 (page 21, lines 31-33; page 22, lines 1-12). After that, we deleted the discussion which was not connected to the research focus in section 4.1 and 4.2 of the original manuscript.

13. Please cite all statements you make.

Response: We have checked the references to ensure all of these are cited.

14. Cites on other emission rates need to explicitly expose their comparability in terms of spatio-temporal scales: are we talking about the same areas and wetlands?, and over the same time period?

Response: The details of other emission rates we cited (e.g., the wetland type and the time period) was shown in Table 2. We also added the information in the other places of the text (e.g., page 16, line31; page 18, lines 26-30).

15. How do these emissions compare to human CH4 emissions from paddy rice?

Response: We compared the emissions between the natural wetlands and the rice paddies in section 4.1 (page 16, 30-33; page 17, lines 1-2). The CH_4 emissions from natural wetlands accounts for ~30% of that from the rice paddies during 2000s (Yan et al., 2009; Li et al., 2006; Chen et al., 2013; Zhang et al., 2011). The decrease is double of the increased CH_4 emissions from rice paddies in China from 1960 to 2009 (1.2 Tg) (Zhang et al., 2011).

16. Management alternatives, role of wetland conservation?

Response: We added some discussion about the wetland conservation on CH_4 emissions in page 20, lines 9-24.

Anonymous Referee #1

1) Section 2.1: It may be better to move the brief description of CH4MOD$_{wetland}$ in Supplement to section 2.1. In addition, I think a more detailed description of the model, including basic model assumptions and structures, is needed. It seems to me that current description of the model only covers model inputs, outputs, etc.

Response: The description of CH4MOD$_{wetland}$ in Supplementary S2.1 was moved to section 2.1 in the revised MS, and additional details were added (page 5, lines 1-26). Additional details regarding the model can be found in Li et al. (2009, 2012).

2) Section 2.2: The author should justify why only two parameters are calibrated. Are these two most important in the model? What about other parameters?

Response: Five parameters (listed in Table S2 in Supplementary) are used in CH4MOD$_{wetland}$. These parameters are mainly related to the plant species (Table S2) and include the proportion of root to total production (f_{root}), the vegetation index (*VI*), the fraction of CH_4 oxidized during plant-mediated transport (P_{ox}) and the fraction of available plant mediated transport (T_{veg}). The values of f_{root} and T_{veg} were obtained from the literature (shown in Table S2). We defined T_{veg} as 1 for grass and 0 for shrubs and trees to indicate that CH_4 can be transported only by ebullition and diffusion in wetlands with trees and shrubs, respectively (Walter et al., 2000). *VI* and P_{ox} signify the differences in the CH_4 production and oxidation capacities among plant species. We added a description of the parameters in section 2.2 (page 7, 1-8) and Table S2 (in the supplementary material).

In our previous studies (Li et al., 2009, 2012), *VI* and P_{ox} were calibrated using measurements in the Sanjiang Plain in region I (Fig. 1), where the wetlands are dominated by *Carex*. However, in other regions, the dominant plant species in wetlands is *Phragmites*, and *VI* and P_{ox} must be recalibrated to reflect the differences between plant species. According to both the editor and the reviewer's guidance, we added the necessity of the model calibration (page 6, lines 23-33) as well as a detailed explanation of why *VI* and P_{ox} should be recalibrated in section 2.2 (page 7, lines 9-13).

3) Section 3: I think "temporal variations" also include seasonal dynamics. I would suggest the authors add some results on seasonal dynamics (or intra-annual variations) of CH_4 emissions in this section. This should be a part of a "comprehensive" study of CH_4

dynamics.

Response: We agree with the comment that "temporal variations" should include seasonal dynamics. In the original manuscript, the seasonal variations of the fluxes at sites were shown in the supplementary material (Fig. S1). Please see Supplementary Material S2 "model validation" in the supplementary material. In the revised MS, we added a figure (Fig. 3 in page 45) to show the seasonal dynamics of the modeled CH_4 fluxes of the five regions from the 1950s to 2000s. In addition, we added a paragraph to discuss the seasonal variations of the CH_4 fluxes and the differences among the five regions in section 3.1 (page 12, lines 27-33; page 13, lines 1-8).

4) Section 4: Some additional discussion is needed to present current knowledge gap in modeling CH_4 processes and large-scale CH_4 emission quantification. How is your CH_4 model different from other CH_4 models? Such as those used in recent CH_4 model inter-comparison studies (e.g., Bohn et al. 2015, Melton et al. 2013). What are present research state and largest challenges in large-scale CH_4 emission simulations? In addition, it is also helpful to compare temporal dynamics of CH_4 (inter-annual, intraannual, trends) in your simulations with other studies.

Response: We appreciate the reviewer's suggestions and have added a discussion of this issue in section 4.4. According to both the editor and the reviewer's guidance, in the discussion, we compare our model with models recently used in inter-comparison studies focused on methanogenic substrate processes, environmental factors and CH_4 oxidation (please see page 21, lines 1-28 in the revised MS). By sharing the common knowledge of methane emissions from flooded soils, the primary processes regarding methane emissions are similar between $CH4MOD_{wetland}$ and other process-based models, such as CLM4Me (Rieley et al., 2011), LPJ-WhyMe (Wania et al., 2010), DLEM (Tian et al., 2010; Xu et al., 2010), Wetland-DNDC (Zhang et al., 2002) etc. However, the $CH4MOD_{wetland}$ model also has its own characteristic. Regarding the modeling mechanism, most of those models were based on land ecosystem models (e.g., LPJ and CLM), which describe comprehensive ecological processes beyond the need of simulating methane emissions. $CH4MOD_{wetland}$ only includes equations that are necessary for modeling methane production, oxidation and emissions and is significantly less complicated than other models. For comparable modeling performances, the simplicity of the model mechanism requires fewer calibrated parameters and simpler variable inputs, which makes the model more applicable for large regions. For example, CLM4Me requires 16 parameters (Table 1 in Rieley et al., 2011) while $CH4MOD_{wetland}$ only requires 5 parameters (Table S2 in Supplementary material). To reduce the estimation uncertainty in the present study, we validated the model using more field measurements at Chinese wetland sites than used in previous studies (Bohn et al. 2015, Melton et al. 2013). Among the models, only $CH4MOD_{wetland}$ considers the effect of salinity on CH_4 production, which improved the model performance in coastal regions (section 2.1).

Change in wetland area is the most important factor for estimating methane emissions from wetlands at regional scales. Compared with previous studies, e.g. Xu & Tian (2012), we used remote sensing data of wetland changes in China (Niu et al., 2012), which provided more reliable information regarding the effects of environmental and anthropogenic activities on wetland changes in China (page 22, 28-33; page 23, 1-9).

In the revised MS, we added some discussion to address the largest challenges in large-scale CH_4 emission simulations (page 22-24). In summary, we think the spatial variability of water table depth, the wetland area, the limited spatial resolution and the rough characterization of vegetation conditions are the largest challenges.

According to the referee's suggestions, we also added a section (section 4.2 in pages 18-19) to compare the temporal dynamics of CH_4 (inter-annual, intra-annual, trends) with observations and the results of other simulations.

Others:

Response: According to the editor's guidance, we have modified the introduction, so some sentences were deleted. We'll give a detail description in the followed responses.

1) P7057 L2: you may update radiative efficiency of CH_4 from IPCC 2013.

Response: We have updated the radiative forcing of CH_4.

2) P7057 L11: delete "e.g.,"

Response: This sentence has been deleted.

3) P7057 L13: change "sinks" to "sources"?

Response: This sentence has been deleted.

4) P7059 L5: delete "and"

Response: This paragraph has been modified. We moved the description of $CH4MOD_{wetland}$ to this section and deleted the original sentence.

5) P7060 L8: what does "vegetation index" mean?

Response: VI is a vegetation index identifying differences in methane production among vegetation types. We added a description of this parameter in section 2.2 (page 7, lines 4-8).

6) P7062 L6: change "assigned to" to "assigned based on".

Response: The sentence has been changed to "The value of a in [Eqn. (1)] was assigned to the coastal wetlands" (page 8, line 32).

7) Figure 4: add (a),(b), : : : (e); delete "at a significantly"

Response: We thank the reviewer for this comment. We have added (a),(b), : : : (e), and deleted "at a significantly" in Fig. 5 in page 47 (original Fig. 4).

Anonymous Referee #2

1) I noticed that the authors used the wetland maps, but it seems that all of them are the "snapshot" of a specific year. The model requires the annual wetland distribution maps; the question here is how did you generate the time series of the wetland maps?

Response: In the present study, we used the $CH4MOD_{wetland}$ model to simulate CH_4 fluxes at each of the grids. Then, we multiplied the modeled CH_4 fluxes by the wetland area in each grid to calculate the CH_4 emissions.

In section 2.8 (page 11, line 19) in the revised MS, we pointed out that the gridded wetland maps of 1950, 1978, 1990, 2000 and 2008 were used in this study. In this study, in order to avoid the uncertainties induced by the method of estimating the annual wetland area, we only made estimation of regional/national CH_4 emissions of the decades which the remote sensing wetland area data available. Throughout the manuscript, we showed the results of the annual CH_4 fluxes (CH_4 emissions per wetland area) simulated by the model (Fig. 4). When we analyzed the national or regional CH_4 emission results in section 3.3 in the revised MS, only the regional or national CH_4 emissions of the specific year were listed (please see Table 1). When calculating the CH_4 emissions for a specific year, the available wetland map obtained nearest the considered year was used (footnote of Table 1).

2) I noticed the soil temperature is from the TEM results. If soil is frozen, how did you handle this situation in the methane simulation?

Response: There are two major sources of CH_4 in frozen soils: (1) CH_4 produced de novo in winter by psychrophilic microorganism and (2) the stored CH_4 formed by mesophilic microbes during the warm period. In our model, CH_4 was transported from the frozen soil to the atmosphere by the standing litter of macrophyte aerenchymatous plants and by diffusion. We compared the simulated CH_4 fluxes with the observations at the Sanjiang site, which has a long freezing winter (Fig. S1 in supplementary material, Fig. 3a in section 4.2, page 18, lines 27-33). Although the simulated CH_4 fluxes matched the observed fluxes well, large biases in the modeled winter CH_4 fluxes occurred because the model lacks a process for simulating thawing, freezing and snowmelt (we added this in section 2.1, the limitation of the model, in page 5, lines 21-26). However, because the methane emission fluxes during the winter are very low, the modeling biases of the winter fluxes have trivial contributions to the annual fluxes.

3) The TEM also has the soil moisture as one output. Is there special reason to select other soil moisture as the input rather than using the TEM output?

Response: To simulate methane production and emissions, soil moisture to the depth of 160 cm is needed for the model used in the present study. However, TEM only provides the soil moisture to a depth of 20 cm.

4) For the wetland pixels indicated by your wetland maps, what if their water tables (from TOPMODEL) are quite low? In other words, TOPMODEL and the wetland maps yield the different wetland extent. How to process it?

Response: TOPMODEL has been extensively used to predict wetland distribution dynamics (Kleinen et al., 2012; Stocker et al., 2014; Melton et al., 2013). However, the simulated wetland change is not sensitive to the impacts of anthropogenic activities that lead to biased estimates of the wetland area (Wania et al., 2013). In China, the dynamics of wetland area are mainly attributed to anthropogenic activities, which cannot be accounted for by the mechanisms in TOPMODEL. In this study, we used wetland change data (Table 1) estimated using the remote sensing approach (Niu et al., 2012) to reflect the wetland changes that occurred in China from 1950 to 2010 (Please see section 2.7). We added a discussion of the uncertainty induced by the wetland extents in section 4.4 (page 22, lines 13-33, page 23, 1-9).

5) What is the time step for your TEM simulation? I remember the TEM is monthly model rather than daily?

Response: TEM is a monthly model that provides monthly soil temperatures. We used temporally linear interpolation to produce the daily soil temperatures as inputs for $CH4MOD_{wetland}$. The interpolation may result in the loss of the temporal variation in the daily soil temperatures; however, in our sensitivity analysis (not show in the MS), adding random variations to the interpolated daily soil temperature data did not result in significant differences (approximate 1%) in the modeled annual methane fluxes.

6) How do you select the decay parameter in the TOPMODEL?

Response: In this study, the decay parameter (*m* in equation S1.1) of TOPMODEL was calibrated using the observed daily water tables at SJ and REG (Table S1). At WLS and LRD

(Table S1), only the average annual mean water table depth was available; thus, we could only use the average annual mean water table depth to perform the calibration. By setting a step increment of 0.1, the model ran for every step value of *m* within 0.1—3.0 until the root-mean-square error (RMSE) between the simulated and observed water table depth was minimized. The values of "*m*" at each site were shown in Table S2. We extrapolated the calibrated value of "*m*" at a site to the region in which it is located. Additional details regarding how we obtained and extrapolated the decay parameter "*m*" are presented in S1 in the supplementary material.

7) I also agreed with the suggestion that the authors should provide the brief introduction to their CH4MOD_wetland model in the Supplemental material.

Response: According to the reviewers' wish, we added a detailed introduction of the $CH4MOD_{wetland}$ model in the manuscript. Please see section 2.1, page 5, lines 1-26.

Reference

An, S. Q., Li, H. B., Guan, B. H., Zhou, C. F., Wang, Z. S., Deng, Z. F., Zhi, Y. B., Liu, Y. L., Xu, C., Fang, S. B., Jiang, J. H., and Li, H. L.: China's natural wetlands: past problems, current status, and future challenges, Ambio, 36, 335-342, 2007.

Bastviken, D., Cole, J., Pace, M., and Tranvik, L.: Methane emissions from lakes: Dependence of lake characteristics, two regional assessments, and a global estimate, Global Biogeochem. Cy., 18, 2004.

Chen, H., Yao, S., Wu, N., Wang, Y., Luo, P., Tian, J., Gao, Y., and Sun, G.: Determinants influencing seasonal variations of methane emissions from alpine wetlands in Zoige Plateau and their implications. J. Geophys. Res., 113: D12303, doi:10.1029/2006JD008072, 2008.

Chen, H., Zhu, Q., Peng, C. H., Wu, N., Wang, Y. F., Fang, X. Q., Jiang, H., Xiang, W. H., Chang, X., Deng, X. W. and Yu G. R.: Methane emissions from rice paddies natural wetlands, lakes in China: synthesis new estimate, Glob. Change Biol., 19, 19-32, 2013.

Giltrap, D. L., Li, C. C., and Saggar, S.: DNDC: A process-based model of greenhouse gas fluxes from agricultural soils, Agriculture, ecosystems & environment, 136, 292-300, 2010.

Gill, R. and Jackson, R. B.: Global Distribution of Root Turnover in Terrestrial Ecosystems, Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/661, 2003.

Jin, H. J., Wu, J., Cheng, G. D., Tomoko, N. and Sun, G. Y.: Methane emissions from wetlands on the Qinghai-Tibet Plateau, Chinese Sci. Bull., 44, 2282-2286, 1999.

Kesik, M., Ambus, P., Baritz, R., Brüggemann, N., Butterbach-Bahl, K., Damm, M., Duyzer, J., Horváth, L., Kiese, R., Kitzler, B., Leip, A., Li, C., Pihlatie, M., Pilegaard, K., Seufert, S., Simpson, D., Skiba, U., Smiatek, G., Vesala, T., and Zechmeister-Boltenstern, S.: Inventories of N_2O and NO emissions from European forest soils, Biogeosciences, 2, 353-375, doi:10.5194/bg-2-353-2005, 2005.

Li, C. C., Narayanan, V. and Harriss, R. C.: Model estimates of nitrous oxide emissions from agricultural lands in the United States, Global Biogeochem. Cy., 10, 297-306, 1996.

Li, C. C., Arvin, M., Reiner, W., Cai, Z. C., Zheng, X. H., Huang, Y., Haruo, T., Jariya, B., and Rhoda, L.: Modeling greenhouse gas emissions from rice‐based production systems: Sensitivity and upscaling. Global Biogeochem. Cy., 18, GB1043, doi:10.1029/2003GB002045, 2004.

Li, C., Salas, W., DeAngelo, B., and Rose, S.: Assessing alternatives for mitigating net greenhouse gas emissions and increasing yields from rice production in China over the next twenty years, J. Environ. Qual., 35, 1554-1565, 2006.

Li, T., Huang, Y., Zhang, W. and Song, C.: $CH4MOD_{wetland}$: A biogeophysical model for simulating CH_4 emissions from natural wetland, Ecol. Model., 221, 666-680, 2010.

Li, T., Huang, Y., Zhang, W. and Yu, Y.: Methane emissions associated with the conversion of marshland to cropland and climate change on the Sanjiang Plain of northeast China from 1950 to 2100, Biogeosciences, 9, 1-17, 2012.

Melton, J., et al: Present state of global wetland extent and wetland methane modelling: conclusions from a model intercomparison project (WETCHIMP), Biogeosciences 10: 753-788, 2013.

Niu, Z. G., Zhang, H. Y., Wang, X. W., Yao W. B., Zhou, D. M., Zhao, K. Y., Zhao, H., Li, N. N., Huang, H. B., Li, C. C., Yang, J., Liu, C. X., Liu, S., Wang, L., Li, Z., Yang, Z. Z., Qiao, F., Zheng, Y. M., Chen, Y. L., Sheng, Y. W., Gao X. H., Zhu, W. H., Wang, W. Q., Wang, H., Weng, Y. L., Zhuang, D. F., Liu, J. Y., Luo, Z. C., Cheng, X., Guo, Z. Q. and Gong, P.: Mapping wetland changes in China between 1978 and 2008, Chinese Sci. Bull., 57, 2813-2823, 2012.

Ramsar, Iran: Ramsar Convention of Wetlands of International Importance, especially as Waterfowl Habitat, Ramsar, Iran, 1971.

Riley, W., et al: Barriers to predicting changes in global terrestrial methane fluxes: analyses using CLM4Me, a methane biogeochemistry model integrated in CESM, Biogeosciences, 8(7), 1925-1953, 2011.

Stocker, B. D., Spahni, R., and Joos, F.: DYPTOP: a costefficient TOPMODEL implementation to simulate sub-grid spatio-temporal dynamics of global wetlands and peatlands, Geosci. Model Dev., 7, 3089–3110, doi:10.5194/gmd-7-3089-2014, 2014.

Wania, R., et al: Implementation and evaluation of a new methane model within a dynamic global vegetation model: LPJ-WHyMe v1. 3.1, Geoscientific Model Development 3(2), 565-584, 2010.

Walter, B. P. and Heimann, M.: A process-based, climate-sensitive model to derive methane emissions from natural wetlands: application to five wetland sites, sensitivity to model parameters, and climate. Global Biogeochem. Cycles, 14 (3), 745–765, 2000.

Wania, R., et al: Present state of global wetland extent and wetland methane modelling: methodology of a model inter-comparison project (WETCHIMP), Geoscientific Model Development, 6(3), 617-641, 2013.

Wei, D., Xu, R., Tenzin, T., Dai, D. X., Wang, Y. S., and Wang, Y. H.: Revisiting the role of CH_4 emissions from alpine wetlands on the Tibetan Plateau: evidence from two in situ measurements at 4758 and 4320 m above sea level. J. Geophys. Res.−Biogeosciences, doi: 10.1002/2015JG002974, 2015.

Yan, X., Akiyama, H., Yagi, K., and Akimoto, H.: Global estimations of the inventory and mitigation potential of methane emissions from rice cultivation conducted using the 2006 Intergovernmental Panel on Climate Change Guidelines, Global Biogeochem. Cy., 23, GB2002, doi:10.1029/2008GB003299, 2009.

Yang, H., Xie, P., Ni, L., and Flower, R. J.: Underestimation of CH_4 emission from freshwater lakes in China, Environ. Sci. Technol., 45, 4203-4204, 2011.

Zhang, W., Yu, Y., Huang, Y., Li, T. and Wang, P.: Modeling methane emissions from irrigated cultivation in China from 1960 to 2050, Glob. Change Biol., 17, 3511–3523, 2011.