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Interactive comment on "Uncertainties in the national inventory of methane emissions from rice cultivation: field measurements and modeling approaches" *by* Wen Zhang et al.

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Reviewer #1: Comments

The manuscript provides a comprehensive analysis of the sources of uncertainty in the national inventory of methane (CH4) emissions from rice agriculture in China. Three approaches were used to estimate the inventory and the associated uncertainties (i.e. direct field measurements, two empirical regression models, and the process-based model, CH4MOD). Additionally, the sensitivity of the levels of uncertainty using each approach to various scenarios of data scarcity was assessed. The more complex, process-based model had the lowest total error compared to the two empirical models. All approaches had higher error when average values were used for input data

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compared to case-specific values, highlighting varying degrees of model instability to insufficiency of supporting data. Interestingly, even when no case-specific input data were used in the processed-based model CH4MOD, it still had lower total error than the least complex empirical model when all case-specific input data were used (i.e. organic matter input modified by water regime). This in-depth comparison of approaches, their associated errors, and the sensitivity of the errors to input data availability is a significant contribution to the scientific community. It examines very relevant issues and challenges that modelers are faced with when scaling up field-validated models to larger spatial scales. The manuscript nicely quantifies and discusses the trade-offs associated with using the different approaches. It also outlines a method for assessing various sources of uncertainty and distinguishing model structural uncertainty from the uncertainty in input data. Re: We greatly appreciate the reviewer's comments on the scientific significance of the study.

-There is no mention of total estimated national CH4 emissions using each approach in the abstract. I actually I think the estimation of national CH4 emissions using the empirical models is missing from the whole paper. It seems like this is a major comparison to include in the paper and highlight in the abstract. Instead, the average CH4 emissions and 95% confidence intervals of the mean are reported. I think a comparison of the national CH4 emissions and their respective 95% confidence intervals for each approach and data-availability scenario is a very important application of this analysis and should be in the abstract. Similarly, I think it is important to highlight which case specific data (e.g. organic matter inputs, water regime, or soil properties) mattered the most in terms of its effect on uncertainty when it was omitted. Re: Many thanks to the suggestion that "a comparison of the national CH4 emissions and their respective 95% confidence intervals for each approach and data-availability scenario is a very important application of this analysis and should be in the abstract". In the revision, we have made the comparison of the national CH4 emissions and their respective 95% confidence intervals for each approach and data availability scenarios. The results of the comparison were showed in Table 3 and the description of the results was also added in the main text

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(P13 lines 3-12 in the 'clean revised manuscript'). In Table 3, the estimated national CH4 emissions ranged from 6.43 (3.79âĂŠ9.77) Tg to 13.59 (1.45âĂŠ38.98) Tg for the M-S0 scenario R1-S0 scenario, respectively. The 95% CIs of the national estimation differed more greatly among the approaches than those among the data availability scenarios of each approach. As an indicator of the trade-off between the complexity of the approach and data availability, the σd/σb+v ratio in Table 3 was 0.87 for M-S0, closer to 1 than those for the other approaches and scenarios, which also yielded the narrowest 95% CI in Table 3. The factors affecting methane emission from rice paddies (e.g. organic matter inputs, water regime, or soil properties) had been incorporated into CH4MOD as input variables. The importance of those factors on uncertainty had been discussed in a previous study (Zhang et al., 2014). Stating briefly, the factor of high sensitivity will result in larger uncertainty when omitted, from water regime down to soil properties and organic matter inputs. As suggested by the reviewer, we also add statement of the total estimated national CH4 emissions in the revised abstract (P1 lines 28-29).

-Overall the paper is lacking in citations of current research articles. Most articles cited are >10 years old. Re: The topic of the present study, uncertainties in the modelling approaches closely related to methane emissions from rice paddies and the relevant, had been dedicatedly discussed in few previous studies (Ogle, et al., 2010; van Bodegom et al, 2002a). In the present study, we compared performances of CH4MOD and two empirical methods that had been developed and utilized in early days (Neue et al., 1990; Khalil et al., 1991, 1993; Bachelet et al., 1995; Kern et al., 1995, 1997), and had to reach out to studies 10-20 years ago. We, however, didn't omit relevant studies in recent years, e.g., the study of mitigating methane emission from rice cultivation by gene transcription (Su et al., Nature, 2015), the study of methanogenic community structure involving methane production (Singh et al., SBB, 2012), and national/global estimation of methane emissions from rice paddies and wetlands (Chen et al., GCB, 2013; Ren et al., Tellus B, 2011; Zhang et al., GCB, 2011). In the revision, we referenced major results of the recent studies concerning methane emission from rice paddies (Ito et al.,

2012; Tian et al., 2016; Weller et al., 2016; Zhang et al., 2016; Dijkstra et al., 2012).

Missing description of model calibration of the two empirical models and CH4MOD.Thus, it's unclear whether data used for model validation (i.e. comparison to measurement-based estimations of fluxes) and uncertainty analyses are independent from data used to calibrate the internal model parameters. Re: The approaches in the study had been used in previous studies (Bachelet et al., 1995; Kern et al., 1995, 1997; Zhang et al., 2011) to estimated methane emissions from rice paddies on regional, national and global scales. When analyzing the performances of the approaches in the present study, we validated them with data excluding those had been used for calibration to maintain the independence between the validation and calibration. We explicitly addressed the situation in the revised MS (P5 Lines 23-24).

It's unclear whether the direct measurements used in the analyses are cumulative CH4 emissions or daily CH4 fluxes from the same experimental plots. If it's the latter, then the errors are not independent, and this issue should be explicitly addressed in the paper. The issue of non-independence of errors was discussed, but it was unclear whether this was due to measurements taken in close proximity versus repeatedly from the same location. Re: All the measurements of CH4 emission in the present study are cumulative CH4 emissions over the period from rice transplanting to harvesting. We explicitly stated it in the revised MS (P10 Lines 13-14). We discussed the non-independence of the measurements due to spatially close proximity in Section 4.1, when no temporal dependence of the daily measurements involved.

Additional comments, questions, and technical corrections: P 1, Lines 26-29: Revise to account for the exception in which M-S3 performed better than R1-S0 (Table 2). Re: We revised the sentence as "Comparisons revealed that the CH4MOD model may perform worse than the comparatively simple regression models when no sufficient input data for the model were available".

P 1, Line 33: Do you mean "between-grid variations", i.e. differences among grid

cells? Re: It is the within-grid variation calculated via the Monte-Carlo method. To make it clearer, we revised the sentence as "the within-grid variations, σT„i, were found to be 81.2%–95.5% to the grid cell means (Fi)."

P 2, Line 2: I think a slight rewording should be made, i.e. "Reducing the total uncertainty in the national methane inventory depends on a better understanding of both the complexity of the mechanisms of methane emission and the spatial correlations of the factors that influence methane emissions from rice paddies." Re: Thanks for the suggestion. The sentence was revised.

P3, Line 16: Reference needed. Re: The appropriate literature references were added.

P 6, Line 12: Provide detail on the parameters and assumptions for substrates produced from added organic matter and root exudates. Re: We added sentences to briefly describe the substrate production from added organic matter and root exudates in the revised Supporting Information (Appendix B). The amount of the substrate derived from rice root exudate was simulated by a power function of the rice biomass, scaled by the parametric influence of the soil context and the rice cultivar. The substrate derived from the added organic matter was calculated by a first-order kinetic decomposition equation of the organic matter in soil, also scaled by the parametric influence of the soil context and the temperature. Details can be found in Huang et al (2004).

P 7, Line 9: Can you provide a reference or derivation of equation 4? Re: We detailed the derivation of Equation 4 in the revision.

P 7, Line 10: Given that the focus of the manuscript is on uncertainty in national inventories, it seems that the methods section should be framed under national-level uncertainties as opposed to regional-level. It's my understanding that national inventories represent an aggregation of multiple regions. Thus, perhaps the section title here should state "national scales" as opposed to "regional scales", and translate this distinction into the text that follows. Re: Thanks for the suggestion. We revised it

throughout the section and other places in the MS.

P7, Lines 28-33: Please clarify each step of the process in which SAND data were obtained. What method of interpolation was used (e.g. ordinary kriging, inverse distance weighted)? What is meant by “missing spatial variation” in your dataset – how was this determined and quantified? Were some grid cells missing survey data all together? Re: Soil properties have extremely high spatial variation and may vary largely from one place not far from another. We obtained the data from Institute of Soil Sciences, Chinese Academy of Sciences, as indicated in the MS. They collected more than 7000 soil profile measurements sampled during the period from 1980s to the present and linked them to the a soil database of 1:1,000,000 scale (Shi et al., 2004), and produced the gridded data of soil properties with geostatistical methods. We compared the spatial variation explained in the gridded datasets of soil properties against the variations in the profile measurements to analyze the ‘missing spatial variation’ (Bodegom et al., 2002b). The ‘missing spatial variation’ is the proportion of spatial variation of the soil properties (the sand content of the surface soil layer in the present study) that were not accounted for by the gridded datasets. We used the missing variation to build the PDF of SAND in Monte Carlo simulation by assuming normal distributions of the missing variation. We added the brief description of the soil property datasets in Appendix B.

P 9, Line 1: Please provide a reference or derivation of equation 5. Re: Equation 5 is derived from Equation (C9) in the Supporting Information (Appendix C) and Equation 4 in the main text, when used in each grid cell. We added the description and derivation in revision (P9 Lines 27-30 and P10 Lines 1-10).

P 9, Line 9-10: You refer to the “three components of the estimation uncertainties” in equation 5. I assume you are referring to (1) (Fj x Br)2, (2) (Fj x CV)2, (3) _DJËĘ2, which is analogous to the three terms in equation 6. Can you please provide a meaningful definition of what each of these components of uncertainty represent? Later in the discussion you explain that (Fj x Br)2 +(Fj x CV)2 represents model fallacy, while

_DJËĘ2 represents uncertainty due to input data. I think including this type of description in the methods section would be helpful to read leading into the results section. Re: Thank for your suggestion. We added explanation of the terms in the revised MS in the method section. In Equation 5, signifies the uncertainty caused by the error and availability of data, (Fi×rb)2 represents the modelling bias, and (Fi×rv)2 represents the rest parts of the model fallacy error apart from (Fi×rb)2. We provided more details of the derivation and explanation of Equation 5 in the Supporting Information (Appendix C) in more general terms than the main text. The three components in Equation 5 do correspond to those in Equation 6 and the derivation from Equation 5 to Equation 6 was also provided in the Supporting Information (Section D).

P 9, Lines 30-31: Explicitly state the water regimes. Re: Revised.

P 10, Line 27: What "estimated CH4 flux" are you referring to? Are you referring to an example of a single flux? If so, I would start the sentence with: "For example, in one case the modeled CH4 flux was . . ., while the measured flux was . . ." Re: Thank you. We revised the sentence (P11 Lines 28-30).

P 11, Lines 16-18: Specify which model the simulated fluxes are based on. Please clarify this in Fig. 6 and Table 3 as well. Re: Thank you for the comments. We added information to specify the model used (P12 Lines 19-20) and the caption of Fig. 6.

P 12, Lines 13-14: Didn't the authors also apply the two regression models to the 10 x 10 km grids? A comparison to the other two approaches (direct measurements and process-based model) should be discussed here. Re: The two regression models were not used to the 10 x 10 km grid in the BGD version of the MS. As suggested by the reviewer, we applied all the three models and data availability scenarios in the revision and list the results in the revised Table 3, focusing on the national CH4 emission and the relevant uncertainties. While there are no measurements on grids, comparison of the estimation by modelling can only be carried among the models (Table 3 and P13, Lines 3-12) instead of against measurements.

P 12, Lines 26-29. Nice explanation! Re: Thank you.

P 14, Lines 19-33. See comment above for P 7, Line 10. Reframe conclusions to include national estimates and uncertainties at the broadest level of discussion. Re: We revised the conclusion and discussion section and added information of the national estimates in both the abstract and the conclusion.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/bg-2016-250/bg-2016-250-AC1-supplement.pdf

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