Biogeosciences Discuss.,
doi:10.5194/bg-2016-37-AC4, 2016

Biogeosciences Discussions
Open Access
EGU

Interactive comment on "Reviews and syntheses: Four Decades of Modeling Methane Cycling in Terrestrial Ecosystems" *by* X. Xu et al.

X. Xu et al.

xxu@mail.sdsu.edu

Received and published: 19 May 2016

[We really appreciate the reviewer for the comments, which significantly improve the manuscript in terms of clarity and organization. All detailed point-by-point responses are listed below.]

This is an excellent and timely review of the current state of process-based methane modeling. While other recent literature on particular methane models typically provide some brief review in the introduction and/or discussion sections, this review paper provides a very useful level of detail for understanding where, how, and why, process-based models of methane differ. As the authors note, these current methane models often poorly reproduce observed patterns, so this is an important reflective manuscript to assess the field before moving forward. That said, I do believe that the manuscript

Printer-friendly version

Discussion paper

could be improved and clarified before publication. There are several relatively minor terms and phrases that require clarification that are detailed below. On a larger point, I think that it would be helpful to provide more information about representations of CH4 processes that are included within ESMs, since this is a major suggestion by the authors. They could include basic information on which models are in ESMs in Table 1, but it would also be helpful to detail plans for future representations.

[We agree with the description of this work, and the needs for more discussion of CH4 model representation in ESMs. We have added one paragraph to summarize how ESMs include CH4 module; what is the likely future direction for ESMs development in terms of CH4 representation.]

Within the conclusions of their review, the authors argue that researchers should focus on the development of a fully mechanistic CH4 model that accounts for all features, and can integrate data on microbial community structure and function. There is always some tradeoff with model complexity and functionality, and I would be more convinced by the authors' conclusions that a more complex mechanistic model should be developed with all components if there was some evidence that this improves simulations over simpler representations. And furthermore, how can the increasing number of plot- to ecosystem-scale measurements of net CH4 flux be used to constrain such a complex model, except for validation? This type of very complex model would even more so require the aggregation of experimental data on microbial ecophysiology that can be used to parameterize and develop robust uncertainties for these processes, and the authors appropriately note that much of this experimental work is yet to be done. It would be helpful if the authors provided some context for understanding how much data exist to constrain these individual CH4 processes (a handful of experiments, or potentially hundreds?) and within which ecosystems. Within the section on model-data integration, I also think that it would be useful for the authors to provide more specific detail regarding ways to integrate these different data types (from net CH4 flux data to process-based experimental data).

Printer-friendly version

Discussion paper

[We have added discussion about the tradeoff of developing a more mechanistic model and a simple empirical model. Meanwhile, the classification of empirical model and process-based model has been expanded. Meanwhile, we totally agreed that constraining mechanistically model is really challenging, yet it is becoming more and more applicable as the scientific community is expanding measurements of CH4 flux and processes, as well as developing new model optimization algorithms. For example, SPRUCE, NGEE-Arctic and NGEE-Tropic projects within DOE are taking this intensive measurements and integration with models. A new model optimization algorithm has been developed associated with CLM framework and ALM framework, we believe the mechanistic models will be more powerful in near future along with these lines of advancements.]

Line by line comments follow: L102-109: I'm confused about the reference number for the percentages: is it the percent of total carbon respiration? Or percent of total methane produced?

[Those percentage numbers emphasize specific processes to the single function of CH4 cycling. For example, acetoclastic methanogenesis contributes to ∼60-100% to the total CH4 production.]

L235: You should also consider citing Matthews & Fung (1987) in this history: Matthews, E., and I. Fung (1987), Methane emission from natural wetlands: Global distribution, area, and environmental characteristics of sources, Global Biogeochem. Cycles, 1(1), 61–86, doi:10.1029/GB001i001p00061.

[We totally agree that the pioneering work by Matthews and Fung is important and should be cited in the manuscript. We have cited it in the revised manuscript.]

Table 1: Since the table is already large, I think that it would be useful to add which models are within ESMs (and if so, which ESM) and which models were developed for particular regions/species (rice, Arctic, etc.).

[We appreciated the reviewer for pointing out this issue. The information of which CH4 models are embedded in ESMs has been summarized in the Table.]

L280-295: I think it would be helpful to add a bit more context for how and why these CH4 models are added into ESMs. The authors recommend that the third group be the focus to understand potential for reduction into ESM models, but what does it take to reduce a CH4 model into an ESM?

[We have added texts to emphasize the importance of representing CH4 module in ESMs.]

L315-330: This section is a bit hard to follow with respect to what exactly the differences are here among the models. I think that it would be useful to restructure this with a bit more of an introduction (like the environmental controls section) about the differences among the four distinct classes of substrate representation, with explicit list of the four classes before listing which model is in each class.

[This section has been re-organized little bit for clarity purpose.]

L345: I'm not sure what the authors mean by "dramatic bias" caused by a lack of representation, and this should be clarified.

[We have revised the sentence to clearly reflect the importance of representing these two mechanisms; the bias in surface CH4 flux will likely be biased if we do not represent these two mechanisms. Studies have confirmed that the surface layer and bottom layer have different mechanisms dominated CH4 production (McCalley et al., 2014), therefore, if we do not consider two mechanisms, we will not be able to simulate this shift and likely the surface fluxes caused by this function shift in response to environmental change. McCalley, C. K., Woodcroft, B. J., Hodgkins, S. B., Wehr, R. A., Kim, E.-H., Mondav, R., Crill, P. M., Chanton, J. P., Rich, V. I., Tyson, G. W., and Saleska, S. R.: Methane dynamics regulated by microbial community response to permafrost thaw, Nature, 514, 478-481, 2014.]

Printer-friendly version

Discussion paper

L363: It's hard to follow the many different categories that the authors are creating, and I'm not completely sure which category three refers to as described here.

[We have revised the manuscript. The three groups of CH4 models are remained, while we changed four groups of methanogenesis to four modeling algorithms for methanogenesis. The classification of three groups of CH4 models have been demonstrated with a cluster analysis as suggested by another reviewer (new Figure 3).]

L370: It would be helpful to provide a bit more context for why Michaelis-Menten representation fails for multi-substrate, multi-consumer networks. Is it purely an equifinality problem?

[We rewrote this sentence to acknowledge the new approach developed by Riley's group. The ECA approach might be good for multi-substrate, multi-consumer biogeochemistry reaction network. We added a short description in this aspect.]

L398: Unclear what "reported these individual processes" is referring to.âĂĺL479: I'm not sure what the "high range" refers to within this context.

[L398 emphasizes the individual processes discussed in previous section. While L479 primarily focuses on processes caused hot spot and hot moments in CH4 flux. In the revised manuscript, we revised those two sentences for clarity purpose.]

âĂĺL567: Unclear what is meant by "integrative tool" . . . for integrative assessment?

[We used "integrative tool" to emphasize that the model can be used to integrate multiple sources of data to reach a better understanding of the system and better budget quantification.]

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-37, 2016.

Printer-friendly version

Discussion paper