

## ***Interactive comment on “Model estimates of climate controls on pan-Arctic wetland methane emissions” by X. Chen et al.***

### **Anonymous Referee #1**

Received and published: 23 May 2015

Review for “Model estimates of climate controls on pan-Arctic wetland methane emissions”

#### General comments

The authors use a land-surface process-based model to identify the dominant climate drivers of northern high-latitude wetland methane (CH<sub>4</sub>) emissions, and to estimate present-day and future CH<sub>4</sub> emissions from Arctic wetlands. The authors quantify the model CH<sub>4</sub> emission sensitivity to precipitation, temperature, radiation and CO<sub>2</sub>. The process-based model and the sensitivities are both used to derive 21st century methane emissions based on CMIP5 climate driver projections. The study results show that CH<sub>4</sub> emissions will be 42% higher in the 21st century, relative to 1997-2006. The manuscript is clearly written: the methodology is well documented, and the results are

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clearly presented.

A major shortcoming of the work presented in this manuscript is that the wetland CH<sub>4</sub> emission climate sensitivity and 21st century predictions are wholly contingent on the model used in this study. However, the authors do not attempt quantify or explore the structural and/or parametric model uncertainty. Given that model parameters are a major source of uncertainty in future flux projections in the carbon cycle (e.g. Booth et al., 2012), I strongly recommend that the authors quantify or characterize the sensitivity of their results to model parameters controlling methane emissions.

It is also unclear whether the model can adequately simulate the inter-annual variability of wetland CH<sub>4</sub> emissions: although the authors have compared the mean annual model wetland CH<sub>4</sub> emissions against a range estimates, the temporal variability of modeled wetland CH<sub>4</sub> fluxes has not been compared against other bottom-up/top-down estimates or in-situ measurements. Given that the seasonal and inter-annual variations of the model's wetland CH<sub>4</sub> emissions - and their response to climatic variability - are a fundamental component of the work presented in this manuscript, the authors should compare the temporal variability of CH<sub>4</sub> emissions against at least one (if not all) of the following: in-situ measurements, atmospheric inversion CH<sub>4</sub> estimates, other model results (e.g. Melton et al., 2013).

Finally, the authors categorize the sensitivity of wetland CH<sub>4</sub> emissions with respect to June-August precipitation (P) & temperature (T), however both observations and models suggest substantial wetland CH<sub>4</sub> emissions in September/October (Chang et al., 2014, Mastepanov et al., 2008, Melton et al., 2013), and hence September/October P and T undoubtedly play an important role. The authors should either extend this period to include September, or should explicitly state why September/October T and P were omitted.

Specific comments

Throughout the manuscript: The term "Arctic" is misleading, given that the study region

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includes all wetland CH<sub>4</sub> emissions at latitudes >45N. Please consider revising.

P5942 L15-L18: “Over the entire period 1948–2006, our reconstructed CH<sub>4</sub> emissions increased by 20%, over 90% of which can be attributed to climate change. An increasing trend in summer air temperature explained the majority of the climate-related variance”. Climate change is a broad term. Please rephrase and/or be more specific.

P5951 L6: “two-dimensional matrices”; it is unclear what the two dimensions of the sensitivity matrices are here. Please clarify.

P5951 L7-L9: Argument is hard to follow, please consider revising.

P5957 L24: “these sensitivities”; presumably these are climate sensitivities. Please be more specific, given that this is the first sentence in this subsection.

P5963 L23-L24: “This is slightly higher than (but within the range of) previous estimates.” The two statements are mutually exclusive, please clarify.

P5963 L25: Conclusion 2 is wholly contingent on the model used in this study. The authors should make this clear.

Table 3: Please be more specific on the method used to derive each methane emission estimate. For example, “literature review” does not adequately explain the method used to estimate emissions, and “WMEM” acronym is not explained in the text or table.

Technical corrections

Figure 6: The “4” in CH<sub>4</sub> not aligned correctly with text.

References

Booth, Ben BB, et al. "High sensitivity of future global warming to land carbon cycle processes." *Environmental Research Letters* 7.2 (2012): 024002.

Chang, Rachel Y-W., et al. "Methane emissions from Alaska in 2012 from CARVE airborne observations." *Proceedings of the National Academy of Sciences* 111.47 (2014):

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Mastepanov, Mikhail, et al. "Large tundra methane burst during onset of freezing." *Nature* 456.7222 (2008): 628-630. Melton, J. R., et al. "Present state of global wetland extent and wetland methane modelling: conclusions from a model intercomparison project (WETCHIMP)." *Biogeosciences* 10 (2013): 753-788.

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