

# ***Interactive comment on “Seasonal and inter-annual variability in wetland methane emissions simulated by CLM4Me’ and CAM-chem and comparisons to observations of concentrations” by L. Meng et al.***

## **Anonymous Referee #2**

Received and published: 11 March 2015

### General Comments

Meng et al., compare wetland methane ( $\text{CH}_4$ ) emissions estimates derived from two Community Land Model (CLM) versions (CN and BGC), and compare the associated atmospheric concentrations against surface measurements of atmospheric  $\text{CH}_4$ . The authors attribute the differences between the two wetland models to the differences in model carbon dynamics. The authors show that the downscaled version of CN performs better against surface observations of atmospheric  $\text{CH}_4$  growth rate, inter-annual variability, and inter-hemispheric gradients during 1993–2004. The work presented in

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this paper makes a significant contribution towards understanding the role of wetlands and carbon cycling in the observed inter-annual variations of global atmospheric CH<sub>4</sub>.

While the authors make a clear comparison between CN and BGC wetland CH<sub>4</sub> fluxes - and the resulting atmospheric CH<sub>4</sub> concentrations - it is not fully clear why the CN and BGC wetland emissions are different. The authors should clarify the link between CH<sub>4</sub> emissions and CLM carbon cycling by including a simple equation to show how wetland emissions are derived (presumably, based on Meng et al., 2012, wetland emissions are derived as the product of wetland extent, heterotrophic respiration and other factors). The authors should also clarify if there are any other differences – in addition to CLM derived heterotrophic respiration – between the CN and BGC simulations.

The authors also state that the CN and BGC models exhibit differences in productivity and below-ground carbon stocks, and show the relative change of NPP and heterotrophic respiration (figure 20). The manuscript would greatly benefit from a quantitative comparison of these terms in the text: please consider comparing the absolute values of CN and BGC carbon pools and mean annual NPP within major boreal and tropical wetland regions.

The manuscript is clearly written and the results are well presented; however, some additional improvements and clarifications are required (specific comments and technical corrections are listed below).

#### Specific comments

The role of nitrogen (and its effect on NPP inter-annual variability) is not mentioned throughout the manuscript. However, this may be a fundamental difference between the models used in this study (CN and BGC) and other CH<sub>4</sub> emission models. Please comment on whether nitrogen cycling in CLM4 is likely to play an important role in inter-annual CH<sub>4</sub> emission variations.

Abstract: The comparisons between modeled and measured atmospheric CH<sub>4</sub> are

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not mentioned in the abstract; however, the title suggests that this is a central component of the manuscript: consider including quantitative results of the model-observation comparison.

P2167 L8-L10: Report the global totals for CLM4Me' wetlands and the range of current estimates by Denman et al. and Kirshke et al.

P2167 L10: What is a "reasonable" overall CH<sub>4</sub> budget? Please quantify, given that subsequent rescalings of CN emissions and anthropogenic fluxes are scaled in accordance with this number.

P2167 L13-24: In addition to the scaling factors (0.72, 0.64 and 0.74) please report the updated mean annual anthropogenic CH<sub>4</sub> emissions for CN\_a, the updated mean annual wetland CH<sub>4</sub> emissions for CN\_b, and the updated mean CH<sub>4</sub> emissions for BGC.

P2169 L3-L8: "First the model is brought close to equilibrium for 1850 surface conditions (atmospheric CO<sub>2</sub> concentration, aerosol deposition, nitrogen deposition, and land use change); however, a 25 year (1948–1972) subset of transient climate data (1948–2004) is repeatedly cycles. Then we use these equilibrated conditions in a transient simulation from 1850 to 1990 to produce the initial condition used in this study". It is unclear which climate data years were used to spin up the model. Please consider rephrasing.

P2172 L10-L11: During which months do the highest and lowest emissions occur within each region shown in figure 5? "Summer" and "winter" can be misleading when used globally outside temperate and boreal climates.

P2712 L25: "This is not surprising given the tropical...". This sentence is misleading, as it implies that interannual differences should scale with the magnitude of the emissions (however, this is not necessarily true).

P2173 L10-L13: For completeness, please consider reporting the mean annual trop-

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ical and boreal fluxes from CN\_b. These are of particular interest, given that CN\_b outperforms CN\_a and BGC when compared against inter-hemispherical gradient and 1993-2004 growth rate observations.

P2173 L13-L16: What are the high latitude differences in wetland carbon cycling? Given the global importance of boreal wetland emissions, and the 8-fold disparity between BGC and CN\_a in this region, a quantification of the “shift of carbon from tropics to high latitudes” (such as the differences between BGC and CN\_a NPP, heterotrophic respiration and carbon pools) would be valuable.

P2174 L1: Are the peak CH<sub>4</sub> emissions rates per unit area or per unit inundated wetland area?

P2175 L22: If these are Pearson correlation coefficients, please state whether these are significant (e.g. state if  $pval < 0.01$ ).

P2175 L25: “The underestimation of N–S gradients in CN\_a might be due to the high tropical wetland emissions. . .”. Could the reduced gradient also be a result of lower anthropogenic emissions in the northern hemisphere?

P2180 L20: “Please note that NPP is closely related to HR”. Given the NPP and HR time-series shown in figure 20, this does not appear to be the case on inter-annual timescales. Please provide a more explicit description of the links between NPP, HR and wetland CH<sub>4</sub> emissions.

Conclusions: Where possible, please quantify terms such as: “strong seasonal and inter-annual emissions” (L4), “large differences” (L6) and “very strong tropical emissions” (L11), “large emissions” (L15), “small wetland emissions” (L16), etc.

P2183 L10-L12: “These simulations generally suggest that the high latitude methane emissions should be somewhere in the broad range between those used in CN\_b ( 7.7 Tg yr<sup>-1</sup>) and BGC ( 97 Tg yr<sup>-1</sup>).” Consider stating that BGC high latitude fluxes ( 97 Tg yr<sup>-1</sup>) are unlikely, given that the BGC simulation inter-hemispheric gradient is over-

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estimated by >50% (figure 10).

Table 1: If possible, please report average annual CH<sub>4</sub> emissions (or 1993-2004 range) associated with each input dataset to this table. For example, you could report mean annual fluxes in brackets as follows “GFED v3 (21)”. This would make it easier to understand the differences between CN\_a, CN\_b and BGC simulations.

Technical corrections

P2164 L28: change “difficulty” to “difficult”.

P2162 L12: “suggest” is ambiguous, given that the wetland emissions from both CN and BGC are known.

P2166 L17: change “selecte” to “select”.

P2171 L11: change “fluxes in different sources” to “fluxes from different sources”.

P2172 L23: Change “There are large increases. . .” to “There are large differences”.

P2713 L11: “. . .to be 63 Tg. . .” check grammar.

P2173 L23: Change “agreements” to “agreement”.

P2173 L24: Change “show” to “shows”.

P2178 L19: change “conducte” to “conduct”.

P2181 L27: change “WETCHIM” to “WETCHIMP”.

P2182 L6: consider changing “extents” to “extent” throughout the manuscript.

P2182 L15: change “which” to “the”.

P2183 L26: change “produce” to “reproduce”.

References: Please add reference for Ringeval et al. (2010).

Tables 3 and 4: Please add units to the numbers or table caption.

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Figures 8,9 11: If possible, please increase the font size.

Figure 14: A horizontally elongated version of this figure could make it easier to see results. Also, this figure shows the same results as table 3 – it may be worth merging the two into a single figure or table.

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Interactive comment on Biogeosciences Discuss., 12, 2161, 2015.

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12, C582–C587, 2015

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