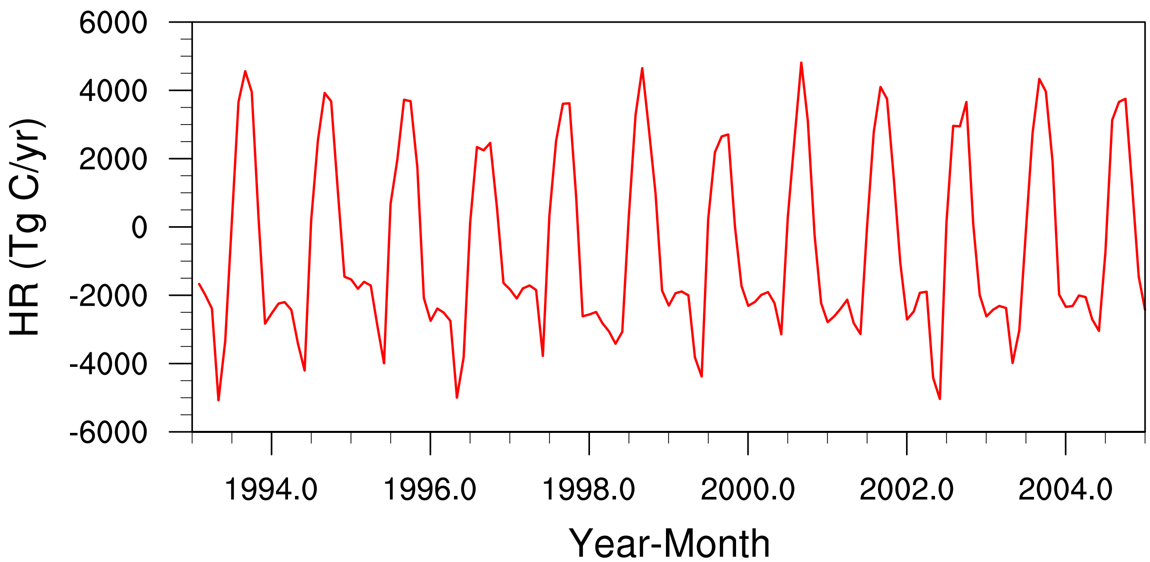
We thank Reviewer #2 for the constructive comments and suggestions. Please find our response below in red.

General Comments
Meng et al., compare wetland methane (CH4) emissions estimates derived from two Community Land Model (CLM) versions (CN and BGC), and compare the associated atmospheric concentrations against surface measurements of atmospheric CH4. 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 CH4 growth rate, inter-annual variability, and inter-hemispheric gradients during 1993-2004. The work presented in this paper makes a significant contribution towards understanding the role of wetlands and carbon cycling in the observed inter-annual variations of global atmospheric CH4. While the authors make a clear comparison between CN and BGC wetland CH4 fluxes - and the resulting atmospheric CH4 concentrations - it is not fully clear why the CN and BGC wetland emissions are different. The authors should clarify the link between CH4 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).

Response: We agree that it is interesting to see large differences in modeled methane emissions between CLM4.0 and CLM4.5. In our original manuscript, we only briefly mentioned that these differences are due to changes in Carbon and Nitrogen model in CLM4.5. In order to provide detailed changes, we added section 3.2.3 to emphasize the major changes that affect soil carbon in high latitudes. Here we quoted section 3.2.3:

The large difference in spatial distribution of methane emissions between CN_a (CLM4.0) and BGC (CLM4.5) experiment is due to the change in soil biogeochemistry and soil C and N models from CLM4.0 to CLM4.5. Koven et al. (2013) conduct a detailed analysis of the effect of such changes on C dynamics in the CLM model. Here we briefly describe the changes that most affect high latitudes C dynamics, where the differences are the largest. The carbon cycle is linked to the Nitrogen (N) cycle because N availability in soils will affect vegetation growth. In the CLM4.0, available mineral N experiences a first-order decay with a time constant of two days that is not subject to environmental limitations. In high latitudes, the long winters will allow most mineral N to *decay and only a limited amount of N is available for vegetative growth during the short growing season. Therefore, CLM4.0 estimates a low productivity and produces low heterotrophic respiration (HR) that is available for conversion to methane production (in CLM4Me, methane production is a function of heterotrophic respiration). In CLM4.5, the dependence of N losses on T and soil moisture and seasonality of N fixation are introduced so that the unrealistic N limitation in CLM4.0 can be reduced. Thus, CLM4.5 allows for more N to be used for vegetation growth and produces higher soil C, higher HR, and thus higher methane fluxes. As shown in Appendix A, HR in CLM4.5 is much higher than that in CLM4.0, particularly in northern hemisphere summer seasons when most of CH_4 is produced. Please note that annual CH4 emissions from northern latitudes are not affected by winter season HR because CH4 is not produced in winter seasons due to below-freezing temperatures. There are other changes made to the Carbon and Nitrogen model in CLM. Please refer to Koven et al. (2013) for details.*

The figure in appendix A is attached here.



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 CH4 emission models. Please comment on whether nitrogen cycling in CLM4 is likely to play an important role in inter-annual CH4 emission variations. Abstract: The comparisons between modeled and measured atmospheric CH4 are 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.

Response: Our added section 3.2.3 can also address the reviewer's concern here. Thanks for pointing out this important issue.

We also added a few sentences in the abstract to reflect the model-observation comparisons on atmospheric CH_4 concentration.

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

Response: the global totals for CLM4Me' are approximately 228 Tg/yr for the period of 1993-2004. The range from Denman et al. and Kirshke et al. is 100-284 Tg/yr. We have also added these numbers on page 8

P2167 L10: What is a "reasonable" overall CH_4 budget? Please quantify, given that subsequent rescalings of CN emissions and anthropogenic fluxes are scaled in accordance with this number.

Response: in this paper, we used ~517 Tg/yr as reasonable because it is within the rage of 491 to 581 Tg/yr in Denman et al. (2014) and Kirschke et al. (2013) and it provided overall best fit between modeled atmospheric CH_4 concentrations and observations (based on Fig. 11).

P2167 L13-24: In addition to the scaling factors (0.72, 0.64 and 0.74) please report the updated mean annual anthropogenic CH_4 emissions for CN_a, the updated mean annual wetland CH_4 emissions for CN_b, and the updated mean CH_4 emissions for BGC.
Response: These numbers are now reported in Table 1.

P2169 L3-L8: "First the model is brought close to equilibrium for 1850 surface conditions (atmospheric CO_2 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.
Response: We modified the last sentence to reflect what we did when creating initial conditions "
Then we use these equilibrated conditions in a transient simulation from 1850 to 1990 (cycled over the period of 1948-2004) to produce the initial condition used in this study."

In other words, we used climate data years 1948-1972 to created equilibrated conditions, then we ran a transient simulation from 1850 to 1990 (cycled over 1948-2004) to produce the initial conditions used in this study. This change was on page 11.

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.
Response: our summer and winter refer to JJA (June, July, and August) and DJF (December, January, Feburary), respectively. We have added the months on page 14.

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).
Response: removed. Thanks,

P2173 L10-L13: For completeness, please consider reporting the mean annual tropical 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.
Response: We have added these numbers on Table 1. Please note that CN_b is CN_a *0.64 for wetland emissions.

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.
Response: our added section 3.2.3 also answer this question. We focused on heterotrophic respiration because our methane production is from heterotrophic respiration.

P2174 L1: Are the peak CH_4 emissions rates per unit area or per unit inundated wetland area?
Response: they are peak CH_4 emission rate per unit area.

P2175 L22: If these are Pearson correlation coefficients, please state whether these are significant (e.g. state if pval < 0.01).
Response: All of them are significant at 95% confidence level. We have added this sentence on page 19.

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?

Response: It could be partially due to the reduction in anthropogenic emissions. However, the reduction in anthropogenic emissions is not big (Fig. 3).

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_4 emissions.

Response: In our wetland model, CH_4 production is calculated from HR, not from NPP. We have added one sentence on page 25 to reflect this). The reason we mentioned about NPP is because we have global NPP values derived from satellites. We assume that if

NPP is close to observations, then HR should also be correct. NPP refers to above ground vegetation growth. HR refers to underground organic carbon. They are related, but not in a strain forward relationship.
We change the sentence to " NPP is related to HR".

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.
Response: We have quantified these terms in the conclusions as much as possible. Please see the changes made to these terms in the Conclusion section.

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−1) and BGC (97 Tg yr−1)." Consider stating that BGC high latitude fluxes (97 Tg yr−1) are unlikely, given that the BGC simulation inter-hemispheric gradient is over estimated by >50% (figure 10).
Response: added.

Table 1: If possible, please report average annual CH_4 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.

Response: Added.

All other technical issued raised by Reviewer #2 are also addressed