RC1

Review Comments for egusphere-2024-1584
Title: Ensemble estimates of global wetland methane emissions over 2000-2020

This is a comprehensive analysis of global inland wetland CH4 emission study that has taken a lot of efforts from many field observations and models. The final result of 158 Tg annual CH4 emission is an important number that fills the gap of current carbon cycle science. I would suggest acceptance after a minor revision.

Response: Thank you for your constructive comments. We appreciate your recognition of the significance of our findings.

Abstract:
It would be good to add the global total wetland area in Abstract.

Response: We have added global total wetland area in the Abstract as follow: *"Our results estimated global average wetland CH_4 emissions at 158±24 (mean ± 1σ) Tg CH_4 yr^{-1} over a total annual average wetland area of 8.0±2.0 Mkm^2 for the period 2010-2020".*

Introduction:
Although a lot of references was mentioned, I didn't see a number or a range of global annual CH4 emission provided by previous studies. If such numbers exist, please try to add the information.

Response: We have modified the introduction to include a range of global annual CH4 emissions as follow:

"Wetlands are the largest single source in the global methane (CH_4) budget, representing ~25-35% of the total combined natural and anthropogenic sources (Kirschke et al., 2013; Saunois et al., 2016, 2020), with an uncertainty range of 100-230 Tg yr-1 (Cao et al., 1996; Gedney et al., 2004; Bousquet et al., 2006; Petrescu et al., 2010; Wania et al., 2010; Spahni et al., 2011; Melton et al., 2013; Bridgham et al., 2013; Bloom et al., 2017; Poulter et al., 2017)."

Methods:
Line 140-143: wetland extent
It would be good to add global wetland area here, or the range of wetland area from those models, or the area from GIESM2.

Response: We have added the wetland area numbers in the sentence as follow:

"The ensemble mean of the modeled wetland extent is close to 7.5 Mkm2 as estimated by WAD2M but higher than the 4.6 Mkm2 by the satellite-based product Global Surface Water Extent and Dynamics version 2 (GIEMS2; Prigent et al., 2020). The modeled temporal variations in wetland areas have high correlations with the satellite-based products for the temperate region and high latitudes (Fig. S1)."

Line 156: Ancillary data.
It would be good to list a few more data items beyond climate data and soil wetness data, e.g., some soil carbon data and vegetation type. I understand those data maybe quite different among the 16 models. Just a suggestion, not a must. Also, maybe list a few CH4-related parameters that most models have in common?

Response: Thank you for the suggestions. Given the level of different complexity and structure in the CH4 modules, it could be potentially misleading if we directly compare the values of parameters among models. Thus we are unable to provide specific values of parameters. Instead, we have listed descriptions about how model implement transport pathways, CH_4 production proxy, and temperature response functions in the Supplement Table S1.

Results:
Figure 1. Nice. But I only see delta CH4 values. Maybe the mean value of the 2000-2009 level should be added in the figure caption? What if you plot the absolute CH4 values on panel 'a'? Should they be the same curves but vary around the mean value?

Response: Thank you for your suggestions. We have added the ensemble mean value for 2000-2009 to the caption of Figure 1(a) as follows: "The horizontal lines represent the ensemble means of 2000-2009 (152 Tg CH4 yr^{-1}) and 2010-2019 (158 Tg CH4 yr^{-1}), respectively." We have included the absolute CH4 values in the Supplement, as showing the changes with absolute values in the main figure is not as visually clear.

Figure 2 a. Visually, I guess panel 'a' can be improved with a more contrasting color scheme. It will be interesting to see the spatial variation on those low value areas. Currently they are all yellow.

Response: We have modified the color scheme to make the plot more color-contrasted.

Line 313: Is it multiple liner regression? If so, add the word 'liner'.

Response: Added.

Figure 3 a. Panel 'a' comparing histogram (frequency) against degree/mm/ppm is unfamiliar to me. No critics here, just make sure you can explain well "The model ensemble suggests that temperature is the primary driver of the increase in eCH4 (Fig. 3a)." What if you use precipitation unit in cm, will that change anything? (I am not quite good at statistics.)

Response: Thank you for the suggestion. Changing the unit for precipitation to centimeters, or for CO_2 concentration, would not alter the pattern of the histogram, as the multiple regression is independent of the units used for precipitation.

Another way to explain why temperature is the primary driver of CH4 increase may be in panel 'b'. I see panel 'b' has regression trend lines, which may show delta T-CH4 relationship is significant because the slope seems bigger. Maybe precip and CO2 impacts are statistically **insignificant**?

Response: Thanks for the suggestion. Yes we agree with the suggestion. The panel 'b' shows that temperature has a significant increasing trend while the trends for change in precipitation and wetland area globally is not statistically significant. We have descriptions in the text as follow: "The links between rising temperature and enhanced net CH4 fluxes are evident (as described below), as the annual global average temperature over wetland areas has significantly ($p < 0.01$) increased by 0.5-0.7 °C from 2000-2020 (Fig. 3b). The modeled interannual variations of wetland extent dynamics reproduced the response to strong climate events (e.g., positive anomaly during the La Niña phase in 2010/2011 (Boening et al., 2012) and 2020). Both climate-forcing datasets suggest no significant trend in the anomaly of annual mean wetland area globally over the same period based on the prognostic hydrological simulations (Fig. 3b)."

Line 366: There are two section '3.2'. The former is on Line 310.

Response: Fixed.

Conclusions:
Line 416-417: "Resolving the large uncertainty in wetland areas and seasonal variation remains a high priority to refine bottom-up estimates of eCH4."
Is it possible to report the wetland areas and/or seasonal variation from the 16 models?

Response: We have added one sentence in the conclusion as follow: *"The prognostic models estimate an annual mean maximum wetland area of 8.0$\pm$2.0 Mkm2, with a seasonal cycle (annual maximum minus annual minimum) of 4.7$\pm$2.0 Mkm2."*