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Biogeosciences Discussions

Interactive comment on "Climate-CH_4 feedback from wetlands and its interaction with the climate-CO_2 feedback" *by* B. Ringeval et al.

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Answer to reviewer 1

We thank the referee 1 for his/her comments and provide detailed answers to all his/her comments below (answers are in bold) :

The paper address the feedback between climate and methane cycle due to changes in CH4 emissions from wetlands. This topic is suitable for Biogeosciences. The paper delivers quantitative estimate for additional rise in atmospheric burden of methane due to this feedback under SRES A2 anthropogenic scenario. Moreover, the paper suggests a conceptual framework for diagnosing interactions between changes in global mean temperature and atmospheric burdens of carbon dioxide and methane. This framework

is original in many respects (but not in all, see next paragraph). All methods employed in the paper are valid and clearly outlined. The presentation is well structured. The language is fluent.

The basic shortcoming of the paper that it does not properly credit earlier work related to the subject of the manuscript. In particular, it is stated in lines 5–6 at page 3223 that "Neither of the previous studies . . . explicitly accounted for changes in CH4 concentration and its effect on CH4" (I guess, this sentence contains a misprint, and "CO2" should be substituted instead of the last "CH4"). This is not true. Explicit response of CH4 atmospheric concentration accounting for feedback between climate and CH4 emission from wetlands and, consequently, for additional changes in CO2 concentration in the atmosphere was considered in (Volodin, 2007: Relation between temperature sensitivity to doubled carbon dioxide and the distribution of clouds in current climate models, Izvestiya, Atmos. Ocean Phys., 44 (3), 288-299, doi: 10.1134/S0001433808030043) and (Eliseev et al., 2008: Interaction of the methane cycle and processes in wetland ecosystems in a climate model of intermediate complexity, Izvestiya, Atmos. Ocean Phys., 44 (2), 139-152, doi: 10.1134/S0001433808020011). The basic result of these two papers was quite similar to that obtained in the present manuscript: feedback between climate and methane cycle substantially enhances CH4 storage in the atmosphere but hardly affects atmospheric concentration of CO2 and global climate. Furthermore, in [Eliseev et al., 2008] an explicit study of climate-methane cycle feedback parameter, defined analogously to the present study, was performed. As a result, it is important to cite both works in the presented manuscript and compare the obtained results with the results reported in these papers (in particular, in Sect. 3.2).

1/ There is no misprint in line 5 at page 3223: in this paragraph, we focus on the β_M sensitivity term, i.e. the effect of atmospheric CH4 concentration on wetland CH4 emissions through its effect on the diffusion between soil and atmosphere. We know this term is negligible but we introduced it to keep a symmetric with

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CO2 equations as explained in lines 15-22 at page 3208.

2/ We believe there is a mistake in the first of the two references given by the reviewer. The correct one should be : Volodin, E. M. Methane cycle in the INM RAS climate model. Izv. Atmos. Ocean. Phys. 44, 153–159 (2008).

Nevertheless, we do agree with the reviewer and now also refer to these two papers in the introduction and in several sections.

*** Introduction:**

We added the two references into the introduction and explained the strategies used at the same time as the strategies of Gedney et al. (2004) and Shindell et al. (2004) are given.

To better answer to the reviewer question, we explain in more details the strategy used in the two papers to compute wetland CH4 emissions in the following lines:
In Eliseev et al., 2008, the module of wetland CH4 emissions integrated into a climate model of intermediate complexity is very simple and does not account neither for change in soil hydrology (both wetland extent and water table depth are constant during all the simulation time) nor for change in methanogenesis substrate. Accounted effects of climate warming on wetland CH4 emissions are only relative to temperature dependency of methanogenesis and to change in soil depth when permafrost thaws. The strategy used in the Volodin, 2008 paper to compute the wetland CH4 emissions sensitivity to climate is more similar to the one we used. Volodin, 2008 accounted for production, oxidation and transport of CH4 but the distribution of wetland area is fixed in time, contrary to our approach.

We also added in the introduction the value of the climate-CH4 cycle feedback parameter found in Eliseev et al. 2008. The Eliseev et al. feedback value is

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not really comparable to ours given the very simple wetland emissions scheme used to compute their wetland emissions sensitivity to climate (see above) and the comparison between the two feedbacks values is not more deeply discussed in the following of the manuscript.

*** Section "Literature based estimate of γ_M and $\beta_{C->M}$ ":**

We added the following text about γ_M:

"Eliseev et al., 2008, found an increase of 130-140 to 170-200 Tg/yr under the SRES-A2 scenario (+3.4°K) but as explained before, accounted effects of climate warming on wetland CH4 emissions are only relative to temperature dependency of methanogenesis and to change in soil depth when permafrost thaws. Both wetland extent and water table depth are constant during all the simulation time and methanogenesis substrate is constant. Such an increase gives a γ_M value of 1.9 GtC/K.
Volodin, 2008 obtained a wetland CH4 emissions increase of +40% from 20th to the end of 21st century (from 240 Tg/yr to 340 Tg/yr) under a warming of 3.5°K (scenario A1B). The results cannot be easily delineated into the theoretical framework we have developed in this paper. For instance, CO2 fertilization effect on wetland CH4 emissions seems to be accounted for (he used NPP to approach substrate) but is not at all discussed. Thus we cannot estimate the γ_M and $\beta_{C->M}$ effects based on this study."

In all of the cases, the increase of wetland CH4 emissions under climate change in these two studies is lower than the one found by Gedney et al. results (see section 3.2) and would not change the range of uncertainty we give in the following of the manuscript.

We also added the following text for $\beta_{C->M}$: "CO2 fertilizing effect on wetland CH4 emissions is not accounted for in Eliseev et al., 2008 (substrate is not considered) and not discussed in Volodin, 2008."

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*** Section relative to the CH4 cycle of the atmosphere:**

A constant CH4 life time is used in Eliseev et al., 2008 as in our manuscript. However, Eliseev et al., 2008 accounted for change in CO2 concentration due to change in oxidation of atmospheric CH4. We now mentioned this when discussing missing processes in our study (line 15 at page 3211).
Volodin, 2008 accounted for CH4 lifetime sensitivity to the concentration. We do the assumption of a constant lifetime to have linear relationship (equation 4b) but we added reference to Volodin, 2008 when discussing this assumption (line 7 at page 3209).

Additional editorial remarks are as follows:

_ Analogously to (Friedlingstein et al., 2006), in Eq. (2) at page 3207 a linear relation between change in CH4 concentration in the atmosphere and global temperature is used. More correct is to get this relationship as a linearisation of more stringent, square root (see, e.g., (IPCC, 2001)) dependence between methane radiative forcing and its concentration. I guess, for reader's convenience, it would be suitable to indicate this procedure explicitly.

We agree with the reviewer. We will add a sentence on this at page 3207 to explain the chosen relationship can also be considered as a linearization of more stringent relationship.
Note also that such simplifications were done to allow us to express the different gains. But the relationships between radiative forcing and gas concentration (IPCC 2001) were used into the manuscript to derive the climate sensitivity to CH4 (α_M) from the climate sensitivity to CO2 (α_C) (line 10 page 3225).

_ Symbol FCF used in Eq. (9) is not defined.

F_{CF} represents the integral over the period (from pre-industrial state to future) of the anthropogenic emissions of CH4. It is the analogous of F_{CM} which is

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defined for anthropogenic CH4 emissions. F_{CF} is used in the Appendix A but is also defined now on page 3207.

_ In line 13 at page 3214, the paper by Ringeval et al. (2011) is cited. This paper does not enter the list of references. Is it the same as Ringeval et al. (2010b) in this list?

This reference has been removed.

_ Possible misprint in line 6 at page 3223 is reported earlier in my review.

See our answer above.

_ Captions for Figs. 1 and 5 report about colour lines. However, these figures are plotted in black and white.

We have now changed this in the revised manuscript version.

_ The panels in Fig. 3 are too small.

We made them clearer for the reader.

Interactive comment on Biogeosciences Discuss., 8, 3203, 2011.