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Biogeosciences Discussions

Interactive comment on "Attribution of spatial and temporal variations in terrestrial methane flux over North America" *by* X. F. Xu et al.

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Comments: This study investigates the terrestrial CH4 surface flux of North America over the last 30 year and the factors contributing to its estimated increase, using a dynamic ecosystem model. The model allows a comprehensive assessment of the influence of what are believed to be the most important drivers, either separately or in combination. The outcome provides important insight into the continental-scale CH4 flux and its response to climate change, which, in my opinion, provides sufficient justification for publication. My main criticism, however, concerns the readability. In its current form, to appreciate the contents, the reader has to make substantial effort trying to understand what is meant exactly. Below are several suggestions for improvement. In addition, I advice a Native American coauthor to have a careful look at the formulations.

Else I have some concerns regarding the treatment of uncertainties and the design of the experiments, which – in my opinion – call for further revisions.

[Response: Thanks for the positive comments. To address reviewer's major concerns, we invited a Native American go over and edit the ms; we also clarified the uncertainties and readjusted the experiment design.]

UNCERTAINTY Reading the abstract one could easily get a false impression of the general level of uncertainty associated with the type of estimates that are presented in this manuscript. The number of significant digits suggests the overall emissions are accurate to better than 1 per mil, and the factorial attribution is at the 1 percent level. Another example is section 3.3 where uncertainties are listed that refer strictly (if I understand correctly) to the linear regression of model generated time series and ignore the substantial uncertainty of the model itself. Those who look more careful find out that the authors make an effort to assess uncertainties. Table 4 lists comparisons with measurements and models and section 4 discusses factors that contribute to the overall uncertainty. What is lacking, however, is the connection between that information and the estimates that are presented in the abstract and the conclusions. When I look at Table 4 I find it very disturbing that under 'N input, wetlands' three numbers are listed (this study and others) that are statistically extremely implausible. The only thing that is mentioned in the text is that the sensitivity to N deposition depends on the level of N limitation. To me it says that the numbers can actually not be compared, which raises the question what the purpose is of their comparison in Table 4.

[Response: This study calculated the uncertainties in portions of the reported fluxes or changing rates, yet did not evaluate the uncertainties associate with the continental and country-level fluxes. Regarding the N input effect on CH_4 flux in wetland; our estimate is in the middle of the reported results from other sources. This comparison shows the reliability of our result. One more purpose of these numbers is to show the huge uncertainties in current study, and might stimulate more research from both experimental and modeling perspectives. So we kept this comparison. Thanks for the

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comments.]

EXPERIMENTAL DESIGN In section 2.3 it is explained that a 3000 year spin-up is needed, supposedly to avoid that initial conditions determine the tendency of the flux in the analyzed period rather than changes in driving factors in that period. In the end it turns out that climate change has largest impact on the flux tendencies. Why, in that case, was the average climatology for the spin-up period constructed from the long-term mean climate for the analyzed period? If I understand correctly it means that the model is equilibrated under conditions (a warmed climate), to test the impact of the same conditions (a warmed climate). If, with this in mind, I look at figure 7 I start wondering whether the negative impact of climate in the first part of the simulation is caused by the fact that initial climate (mean of 1979-2008) represents more warming than the first part of the simulation. In this respect, the definition of the baseline is crucial. If I understand right, the accumulated baseline flux for the period 1979-2008 is calculated by assuming that the 1979 flux remained constant for the analyzed period. However, if the conditions in the model were kept constant at the 1979 level during the analyzed period, the fluxes would probably still experience a trend. In a worst case, one could think of the initial conditions explaining most of what happens after. Why is the baseline defined as the 1979 flux and not the result of a simulation that recycles the 1979 conditions? These issues should be clarified.

[Response: We chose 3000 year spin-up to minimum the influences from land use change. For example, the wetland conversion to crop; since the soil carbon in natural wetland is relatively high, while is quite low in cropland. So it needs thousands of years to drive model to state for further cropland simulations.

For the baseline issue, we really appreciate the reviewer for pointing out the climate influence. It might be due to the fix baseline in 1979 as we used in the previous version. In the revised manuscript, we use the baseline flux as modeled result during 1979-2008 without driving force changed. The first part of the simulated climate impact was eliminated.]

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THE ROLE OF CLIMATE It is unfortunate that there is a single factor that influences the simulations much (climate change), and a few others that have a relatively minor impact. I'm not surprised that the combined effect is not much different from the sum of the components (given realistic overall uncertainties), because climate change dominates the outcome anyway. It would have been more interesting to understand how exactly climate change influences the fluxes, which suggests another factorial analysis, targeting various aspects of climate change. I understand that this would probably be an unfair requirement. Nevertheless the paper would become much more interesting if some attempts are made to better understand how climate change affects the fluxes.

[Response: Thanks for the comments. In the revised manuscript, we have partitioned variations induced by climate change to individual climate variable. We identified the precipitation as one of the major factor on CH4 flux; the interactions among temperature, precipitation, solar radiation, and relative humidity also made substantial contributions.]

TECHNICAL CORRECTIONS Abstract line 10: Break the sentence before 'all'

[Response: This has been revised in the new version manuscript. thanks.]

Page 5385, line 16: 'reality' instead of 'real reality'

[Response: Mistake corrected; thanks.]

Page 5385, line 19: None of the identified factors address transport.

[Response: We have revised the sentence to make it clearer. thanks.]

Page 5385, line 25: 'Enhance flux by stimulating emissions'. Because an emission is a flux this doesn't make sense.

[Response: We have revised the sentence, thanks.]

Page 5389, line 24: Would wetlands count as water bodies that are excluded? I suppose not, but what does count under water body here?

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[Response: Thanks for the question; the natural wetland is one of the major biome types across North America. The water body in this study is defined as big lakes and rivers with a great amount of water volume which are usually excluded from natural wetland.]

Page 5389, line 26: A reference to NARR is missing.

[Response: Missing reference added; thanks.]

Page 5390, line 7: A reference to HYDE is missing.

[Response: Missing reference added; thanks.]

Section 3.3 and section 3.5: It is almost impossible not to get lost in the numbers while reading these sections. Numbers that are in tables need not be repeated in the text (except maybe a selection of a few particularly relevant ones). More examples of this can be found in other sections.

[Response: We have heavily revised these sections; the exact numbers are referred to tables. The major numbers were emphasized in the text.]

Page 5393, line 18: ppb.h instead of ppb h-1

[Response: Mistake corrected; thanks.]

Table 1: There is no need to repeat the entries of the table in the caption. Somehow this table should inform the reader that the numbers are derived by regression analysis.

[Response: We have heavily revised Table 1 (Table 2 in the new version ms). We have also shown that the regression was used to obtain these values.]

A 'Changing trend' would be the second derivative of a parameter, whereas the first derivative is meant (or just 'trend').

[Response: Mistake corrected; thanks]

Table 2: Which year or period do the numbers refer to?

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[Response: It is for the entire study period of 1979-2008. We have put this information in the table caption.]

Figure 3: The O3 pollution map looks strange to me. I would have expected the densely populated regions to stand out, instead of e.g the Rocky Mountains. The caption should provide information on the threshold that was used for N-fertilization. PPB.H instead of PPB/H.

[Response: The O3 pollution distribution map over the North America is not consistent with population density. This could be found in Felzer et al., 2004. We have revised the O3 unit, thanks. The nitrogen fertilization occurs only in cropland; so in the map, no fertilization was shown across natural vegetation.

Felzer, B., Kicklighter, D. W., Melillo, J. M., Wang, C., Zhuang, Q., and Prinn, N. R.: Effects of ozone on net primary production and carbon sequestration in the conterminous United States using a biogeochemistry model, Tellus, 56B, 230-248, 2004.]

Figure 4: This figure doesn't convey much information. The panels are virtually the same. I propose to use one figure for the total flux and plot the others relative to it in order to highlight differences.

[Response: We have revised this figure; only one figure was shown.]

Figure 6: The figure does not fit into the page.

[Response: We have revised the figure, thanks.]

Figure 8: There is no reference in the text to this figure. [Response: We have added the reference to Figure 8 in the text, thanks.]

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