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## **Comment on bg-2022-55**

Anonymous Referee #1

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Referee comment on "The importance of spatial resolution in the modelling of methane emissions from natural wetlands" by Yousef Albuhaishi et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2022-55-RC1>, 2022

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Title: The importance of spatial resolution in the modelling of methane emissions from natural wetlands

Author(s): Yousef Albuhaishi, Ype van der Velde and Sander Houweling

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This paper aims to evaluate the impact of spatial resolution in methane emissions estimate from wetlands. The authors hypothesize that methane emissions uncertainties can possibly be reduced by employing high-resolution (HR) wetland maps. In order to challenge this hypothesis series of simulations of the Fennoscandinavian area at resolution ranging from  $0.001^\circ$  to  $1^\circ$  using a simple methane emissions model are employed.

## General comments:

The goal of the paper is of interest for the scientific community and the approach seems interesting but because the paper is not easy to understand doubt remain on the approach. For instant, some details are missing in sections 2 and 3 that are explained later in the results or discussion sections and reduce the clarity of these sections. For example, in section 3 maps resolutions are provided but not explanation is given on how maps are rescaled or not to be employed for the simulations at various resolution. Then the results description in section 4 is fine but is structured with too many sub-sections. The content of the result section can stand with no subsections, I believe. While results are consistent with the previous section 1 to 3, the discussion section 5 is disappointing. There is a discussion on the wetland map resolutions and a reanalysis of wetland extend of models employed in the WetChimp model intercomparison paper of Melton et al. (2013) and a very small discuss on methane emissions and on the actual simulation results of the paper. It is also disappointing not to have some discussion on the complexity of methane emissions models for example for models employed in the WetChimp model intercomparison versus the simple model employed here. The main conclusions of the paper is that wetland distribution is the main uncertainty for methane emissions and it has been demonstrated using a simplified model and conceptual framework. However, this uncertainty has already be addressed and demonstrated in a different manner in the paper of the global methane budget by Saunois et al. (2020) by comparing methane emissions estimated by 13 land surface models using the same wetland map.

For all the above reason, I recommend some major revisions of the paper before to be reconsidered for publication. Below are some comments to help the authors revising the manuscript.

## Specific comments:

- Abstract: Line 13 the rang of resolution, from 0.005° to 1° resolution, indicates in the abstract is different than the one in table 3 that range from 0.001° to 1° resolution. Could you explain why? You show results at 0.001°, even though it is employed as a reference, it is still compared to the other runs.

- Units: Sometimes the resolutions are given in different units than degree such as in line 147, 191 and 256; please make sure that all the units are the same for each variable. Also, some numbers in the text are formatted using scientific notation, others are not, such as in lines 298-303. It will ease the reading of the paper to have the same format of

numbers.

- Although, the author sometimes qualifies the methane model by "highly simplified model" I think the model is a "simple model".

-Figures and Tables:

- I believe that Figure 1 and 2 can be merged into one single figure and by adding case 1 next to the content of Figure 1, case 2 next to the content of figure 2 and adjusting the figure caption.

- Figure 3 can be removed, it is not useful to understand the paper. Possibly it can be placed in the appendix or supplementary document.

-Figure 4: My understanding is that you also run Sn 1 at 0.001° resolution which is also you "reference resolution" why does it not appear in Figure 4?

-Figure 5: the axis labels are not clear what is the right y axis, methane concentration? methane emissions? and the left y axis which ratio is it? Figure captions should describe more the figures. Also, I would advise to modify Sn.1-Sn.3 to Sn.1 to Sn.3 to avoid any misunderstanding such as the difference between Sn.1 and Sn.3

-Figure 6: please add the resolution for each box diagram in larger characters. Also, axis need labels that describe each axis in addition of the units. In each box diagrams all text should be enlarged except for the boxes with  $K_{CH_4}$ .

-Figure 7-8-9 and A2: the text is very small as well but map sizes are fine.

- Figure 10: It is the correlation matrix of wetland extent? Please add this detail in the caption

-Table 1: The table caption needs to provide all details for the reader to understand the table. All acronyms need to be defined in the caption.

- The title can possibly be modified to :“ Spatial resolution significance in methane emissions modelling of natural wetlands”

-I think a better suited subtitle for section 2.1 could be “conceptual framework”

In this section the author explains the conceptual framework that they employed to evaluate wetland, soil organic carbon and soil moisture maps resolution on methane emissions. They use two cases: (1) an area entirely covered with wetlands and (2) the same area with one half cover with wetland and the other half with uplands. Both cases are well described however the aim of this section is not obvious.

- It is unclear to me the transition between the calculation of methane emissions over the all-domain area (up to line 105) and the calculation of methane emissions only for wetland areas (after line 105). Indeed, for case (2) the authors make the hypothesis that for uplands soil organic carbon and soil moisture are null then resume equation 2 and 3. Because of this hypothesis both equations serve to estimate methane emitted only by wetlands. This suggests that uplands are not emitting methane whereas simulation protocols defined for scenario 2 and 3 suggest otherwise which is confusing.

- In addition, I do not understand how the average of the SC or SM of the wetlands and the uplands over  $A_{HR}$  (which for me is  $(n_{wl} SC_{wl} + n_{uplands} SC_{uplands}) / (n_{wl} + n_{uplands})$ ) is equivalent to the average of SC or SM of only wetlands over  $A_{HR}$  (which is for me  $n_{wl} SC_{wl} / n_{wl}$ )? Because it is SC or SM that is equal to zero and not  $n_{uplands}$  (which gives after simplification  $(n_{wl} SC_{wl}) / (n_{wl} + n_{uplands})$ ). Then, if I am not mistaking, in equation 3 :  $E_{HR} = [n_{wl} SC_{wl} / (n_{wl} + n_{uplands})] \times [n_{wl} SM_{wl} / (n_{wl} + n_{uplands})] \times A_{HR} = [n_{wl} / (n_{wl} + n_{uplands})]^2 \times SC_{wl} \times SM_{wl} \times A_{HR}$  and equation 4:  $E_{HR}/E_{LR} = [1 / (n_{wl} + n_{uplands})^2] \times A_{LR}/A_{HR}$

If I am mistaking, I need some explanations to understand the equations in the manuscript.

- It is also unclear to me, at this stage of the paper, what the wetland fraction  $F_{wl}$  represent? In equation 4  $F_{wl}$  is defined as the proportional ratio of methane emissions estimated using LR map over the HR map. Therefore, to me  $F_{wl}$  is a ratio of methane emissions and not a fraction of wetland area. It is only because of the hypothesis that uplands are emitting no methane that the emission ratio is directly proportional to the wetlands fraction but it not clearly explained in the text.

- In section 2.2, the authors define the wetlands methane model and scenarios that are simulated. It is not clear which model/method there are using to simulate these scenarios, equation 2-3 or equation 1?

-Line 132-133: It is explained that it is considered that upland does not emit methane but in the next sentence methane emissions are still simulated for uplands? Then lines 135 – 137 seem to be some results or results discussion rather than method description.

-Line 176: Scenario 5 is not in table 1? Could you define it somewhere?

-Line 178-179: "The underlying assumption is that soil carbon in the ISRIC map is limited by the peat fraction at 250x250m resolution, and that the highest values represent grid boxes that are fully covered by peat." Finally, how much peatland area is estimated for the total area domain considered?

- Line 200-201: "This gives rise to variations in soil surface temperature that we are unable to account for but are assumed to be second order in importance compared to variations in soil carbon and soil moisture." In the present study, authors may considered soil temperature as secondary however in sensitivity analysis of more complex methane models that represent methane production, oxidation and transport in global land surface models show that soil temperature is the first variable controlling methane emissions before soil carbon content and soil moisture (van Huissteden et al., 2009, <https://doi.org/10.5194/bg-6-3035-2009>; Riley et al., 2011, <https://doi.org/10.5194/bg-8-1925-2011>; Salmon et al., 2022, <https://doi.org/10.5194/gmd-15-2813-2022>)

- At the end of section 3, it is unclear which map resolution is employed for the SC, SM average soil temperature and wetland maps for each scenario?

- In section 4, I believe that subsection's titles 4.1 to 4.4 can be removed.

- Line 222: "Significant differences are seen across the wide range of scales from the reference resolution to the coarsest resolution of  $1^0 \times 1^0$ " why does the reference resolution is not displayed in Figure 4?

- Line 224 "the reference resolution integrated  $\text{CH}_4$  emissions is  $\sim 1.68 \text{ Tg CH}_4 \text{ yr}^{-1}$ " please add Table 3 in the text such as "the reference resolution integrated  $\text{CH}_4$  emissions (Table 3) is  $\sim 1.68 \text{ Tg CH}_4 \text{ yr}^{-1}$ "

-Line 237 "Figure A.1 compares total CH<sub>4</sub> emission for the study area obtained using prescribed values for SC and SM in Table 2." How do you obtain uplands emissions since in lines 132-134 you explain that equation (5) does not apply?

- Line258 : "This is done in two ways;" what is the second way?

- Line 292 : "Secondly, the representation of wetland area in models is associated with large uncertainties." Please explain further the large uncertainties?

-From line 294 to 311, I believe that the figure numbers do not correspond to the right figures. Please check the figure numbers in the text.

Technical corrections:

Line 13: replace "that is coarsened in six steps from 0.005° to 1°." To "at resolution from 0.005° to 1°.

Line 24: replace "improve the accuracy of models, the main message of this study" to "improve the accuracy of models. **The** main message of this study"

Line 90: "the availability of soil carbon" do you mean soil **organic** carbon or soil carbon that include organic and inorganic carbon?

Line 91: "that we will use in the remainder of this study" this could be modified to "that we will use in this study"

Equation 2 is right only if SC and SM of each High-resolution grid box are equal and if SC and SM for uplands are nul.

I do not understand what the wetland fraction corresponds to? For me it is the proportional ratio of CH<sub>4</sub> emissions at Low resolution over high resolution.

Line 110: Are "the grid boxes that covered by wetland" **entirely** covered by wetlands?

Line 121: "the number of model parameters is only small" please modify to "the number of model parameters is small"

Line 122: "the basic CH<sub>4</sub> controls of soil temperature" please modify to "soil temperature"

Line 128-130 "KCH<sub>4</sub> is a calibration constant relating the driving variables to a CH<sub>4</sub> flux in units of [g CH<sub>4</sub> m<sup>-2</sup> yr<sup>-1</sup>]. We want to note here that **The** input data used in Eq.5 are for year 2015 as will be **and are** described in section 3.2." please modifies to "KCH<sub>4</sub> is a calibration constant relating the driving variables to a CH<sub>4</sub> flux in [g CH<sub>4</sub> m<sup>-2</sup> yr<sup>-1</sup>]. **The** input data used in Eq.5 are for year 2015 **and are** described in section 3.2."

Line 145: "For the remained scenario" please modify to "For the last scenario (Sn.4)"

Line 146: "(5arcmin)" please confer to resolution degree.

Line 156: "that are reporting" please modify to "that are reported"