

Interactive comment on “The limits to northern peatland carbon stocks” by Georgii A. Alexandrov et al.

Anonymous Referee #2

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General comments: In this manuscript, Alexandrov et al. present and discuss the estimates of northern peatlands carbon stocks using different approaches (conservative, non- and less-conservative approach). The procedure to calculate the total carbon content for the northern peatland areas have already been developed but in this study, authors have revised some values which they have estimated using the gridded soil dataset. The study has the potential to reduce the current uncertainties related to the

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limits of peatland carbon stocks and it is worth publishing. However, I find there are many sections which need to be strengthened, particularly, the methodology and result sections. I also recommend them to divide the methods section into several parts under different sub-headings and include a brief explanation about the model in the beginning. In the introduction and discussion sections, many arguments need to be referenced (see my comments below). More importantly, the authors have assumed that peatland distribution areas have not much been changed since the last 5000 years and the growth in the peat height was a major cause of carbon uptake in the northern areas. However, according to MacDonald et al. 2006 (see Figs. 1 and 3), around 30-40% peatlands were initiated after 5000 cal. B.P. which means that the increase in new peatland areas has also played a significant role in sequestering atmospheric carbon. How do they explain this assumption?

Specific comments:

P1 L18: How did you define northern peatlands (> 40°N or 45° N)?

P1 L19: “The variations are explained by” . . . Which variations?

P1 L22: “However, during the last 5000 years, the area of peatlands remained relatively stable. . .”

Peat basal ages are used as proxies to identify new peatland areas and expansion rate. From figures 1 and 3 in MacDonald et al. 2006, we can see that around 30-40% of the peatlands were initiated after 5000-year cal. B.P in northern areas. Therefore, I doubt whether the growth in the peat depth is the only major cause of carbon uptake in the past.

P1 L25: “the northern peatlands may accumulate 864-2200 PgC . . .”

This is a very high value, how did you calculate this range. From where did you find this information? What about the peatland distribution area and sink capacity, will they remain the same in the future? Studies indicated that many peatlands would lose their

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carbon sink capacity while some may enhance.

P2 L 1-15: Support your arguments with previously established knowledge. Include references.

P2 L5: Define what a steady state is for your readers.

P2 L6: How did you estimate this range – see my previous comment.

P2 L9: Remove this expression – “the so called”

P2 L11: “at least a small portion of the organic matter that enters the acrotelm always reaches to the catotelm . . .”

Is this a plausible argument – do you think, acrotelm always passes organic matter in the catotelm? Even when peatland experiences continuous dry conditions?

P2 L 13-15: In which study, did you find this information?

P2 L 16: Could you explain a bit about your model. What it does and other relevant information briefly and give more details in the methods section.

P2 L 22: “The gridded data on soil properties give the fraction of a grid cell covered by peatlands . . .”

Include reference.

P2 L27: How did you determine where to form a cluster in a grid cell?

P2: I think a paragraph needs to be added in the end which explains the purpose of your study.

P3 L1: Methods

Perhaps subheadings could be helpful to improve and clarify the structure of the methods. I also suggest you to add a model description section.

P3 L3: “The density of the draining system” – explain what it is?

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P3 L4: “The impeded drainage model approach” – Give more details about this approach and model. What it is and where this approach has been used before?

P3 eqn 1 - From where this equation comes from? Any previous applications? Please clarify.

P3 L7-8: it is better to include the value of constants in the equation or under it.

P3 L10: There are many peatlands in the southern latitude region between 45-55°N, particularly in China, U.S and Magnolia. Have you considered them in your calculation?

P3 L11: Include a brief write up about the SoilGrid dataset and what it contains.

P3 L18: Did you check the recent study by Xu et al. 2018 where the authors have refined the global and regional estimates of peatland distribution area? How your dataset (WISE30sec) is different or better than Xu et al. 2018 (PEATMAP)?

P3 L22: If you have the dataset then you can easily estimate how much area is occupied by northern peatlands. According to Xu et al., around 3.12 million km² area is occupied by peatlands above 45°N and Yu et al. 2010, used 4.0 million km².

P4 L: How accurate are these conservative and non-conservative estimates? From Table 1, one can see that both estimates fail to capture the observed peatland carbon density. In fact, in some cases, the conservative estimates are higher than the observed values. Based on this information, do you think we can rely on your modelled limits?

P4 Results: This looks like a part of the discussion. I recommend you to explain your results and what you see in your figures before comparing them with the previously established knowledge. For example, you can highlight how much peatland carbon stocks you have estimated in the European, Russian and N. American regions, which areas are rich in carbon within in these regions, what are the maximum and minimum peat depths, why you used a constant bulk density value etc.

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P4 L27: You can also include the eqn used by Gorham 1991- $C_{peat} = P_i (A_i \times D_i \times B_{Di} \times C_{Ci})$

P4 L29: $112 \times 103 \text{ g m}^{-3}$ - Change it to 112 kg m^{-3}

P5 L4: Explain what time history approach is.

P5 L15: There are other methodologies which have been developed to estimate total carbon stocks (see Yu et al. 2012). How your approach is different or better than these methodologies and what are its limitations?

P5 L18-22: No references.

P5 L16: "We adapted this methodology for use at the global scale . . ."

Global or regional because you have considered only the northern peatlands?

P6 L7: "If there were no limits to their growth. . ."

In the introduction, you have mentioned that peatlands can reach to steady state and do not grow or accumulate carbon after that. Do your analysis shows in which regions peatlands have already reached to steady state?

References: 1. MacDonald GM, Beilman DW, Kremenetski KV, Sheng Y, Smith LC, Velichko AA. Rapid Early Development of Circumarctic Peatlands and Atmospheric CH₄ and CO₂ Variations. *Science* 314, 285-288 (2006).

2. Gorham E. Northern Peatlands - Role in the Carbon-Cycle and Probable Responses to Climatic Warming. *Ecol Appl* 1, 182-195 (1991).

3. Xu JR, Morris PJ, Liu JG, Holden J. PEATMAP: Refining estimates of global peatland distribution based on a meta-analysis. *Catena* 160, 134-140 (2018).

4. Yu ZC. Northern peatland carbon stocks and dynamics: a review. *Biogeosciences* 9, 4071-4085 (2012).

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