Response to Referee #2 (Dr. Tupek)

We would like to thank Dr. Tupek for his thoughtful and constructive review, as well as his detailed comments. Our responses to all of the referee's comments are italicized below.

Authors tested SOC simulations from the modified version of their Terrestrial Ecosystem Model (TEM) for peatlands (P-TEM) for Alaska region for time periods defined by climatic characteristics (solar radiation, temperature, and precipitation levels) and vegetation distribution during last 15 000 years. The model was applied for peatlands and non-peatlands (mineral soil forests). Simulated C distributions, NPP, and peat depths were presented for Alaska at fine scale spatial resolution (maps) and summarized for vegetation types. This can be an interesting study if presented carefully

We agree to make all edits and changes brought up by the referee. We respond to the comments below.

The advances of the model include hydrology, soil thermal, C and N dynamics modules. This looks promising however, the model code is not publicly available and need to be asked from authors. No software details were given. I'd like to see the code and run an example simulation in R to understand the model structure. Description of NPP simulation by the model is missing. Description of Carbon and Nitrogen dynamics of CNDM module is also missing. Add descriptions for clarity. Results largely depended on the adopted distribution of vegetation types. Authors mentioned that distribution of vegetation types and their changes overdriven C accumulation over climate, but also noted that climate had probably driven distribution of vegetation types. Individual parameter values are not listed. It would be interesting to see the changes of key parameters between vegetation types in relation to their prevailing climate.

The descriptions of P-TEM including modules of STM, HM, CNDM, and MDM are less listed in this manuscript. The main reason is that we have described the model framework, specific parameters and the parameterization processes, along with the comparison between simulation and observation regarding soil moisture, methane emissions, water-table depth, and carbon and nitrogen dynamics in the previous study. Please find the paper "**Quantifying Peat Carbon Accumulation in Alaska Using a Process-Based Biogeochemistry Model"** for details (*Wang, S., Q. Zhuang, Z. Yu, S. Bridgham, and J. K. Keller (2016), Quantifying peat carbon accumulation in Alaska using a process-based biogeochemistry model, J. Geophys. Res. Biogeosci., 121, doi:10.1002/2016JG003452.*).

The paper was under review by JGR-Biogeosciences at that moment so there was no way we could cite that paper. However, it was just published and we have cited it during the revision of this manuscript. Besides, as an introduction to a newly built model (P-TEM), that JGR paper cited other references which have all the individual modules and their applications discussed in detail (e.g., see Zhuang et al., 2001 JGR, Jiang, Y. et al., 2012 JGR for STM module; Zhuang et al., 2002 JGR for HM; Zhuang et al., 2004 GBC for MDM; JW Raich et al., 1991; 1992 for CNDM). Also, please find all references with Terrestrial Ecosystem Model in use at: http://www.eaps.purdue.edu/ebdl/publications/index.html

Description of observations of peat depths that were used for model validation is not sufficient. Some description is in section 2.5 but it is not clear and the points on the maps in Fig. 2 are barely visible. Describe clearly.

The manuscript highlights the method and the result, however, has less emphasis on the model validation with observed peat depth distribution. We strongly agree to add more contents discussing the model validation and the use of observed peatland basal ages, as mentioned in section 2.5. We also agree to change the symbol size in Fig. 2 to make the figure much clearer to readers.

Structure of the paper is unclear. Reorder the ideas, avoid using repetitions.

We will reorder the ideas and make it more logical to readers.

Methods are presented in results. Results are presented in discussion. For example lines 369-370 in results describe how peat depth was calculated for the first time. Discussion Section 4.3 presents too many numbers without deeper insights on reason behind differences between other studies. At the end of discussion a scatterplot Fig. 14 between observed and modeled peat depths is presented for the 1st time. The Fig. 14 shows that without exceptional agreement of 3 largest values the rest of the scatter is just a gunshot indicating poor performance of the model in most conditions. Authors avoid the explanation. Move results to result section. Present some values in Tables. In discussion interpret the results with a focus on the model and data input.

Interesting results as underestimation in uplands, lack of C loss simulation (Fig. 2), reasons behind vegetation controlling C storage, disagreement with observations, assumption that peatlands will remain C sink are brushed away. The agreement with other studies is OK but not enough for discussion. Describe reasons for agreement/disagreements, give insights on function/performance and reason why to use/trust your model. Although the authors claimed that the PTEM includes CN module, nothing can be learned from reading the paper how this or other modules affect the results. Given the SOC underestimation of uplands and large scatter with peatlands, and large-scale climate estimates, could accounting for differences in nutrient status or reevaluating response of C/N ratio be a key for improved estimation of spatial variability of SOC accumulation of P-TEM or TEM model?

Many results and conclusions were obtained from this study. We agree to reorder the structure and make the results more concise and focused. Tables will be added to present the findings more clearly. The discussion section will be reorganized and results will be analyzed in detail. We will put more discussion on model validation and the relationship of vegetation distribution, climate change, and carbon accumulation rates. We will also cite the newly published JGR paper as mentioned above to give readers a clearer vision on P-TEM model framework and its application to Alaskan peatland.

Authors claim that recent climate is warmer and wetter in summers and therefore with future warmer-wetter climate peatland carbon sink will continue. Possibility of increased respiration and C loss due to droughts or warmer winters is not mentioned. For the conclusion on future C sink a simulations with climate scenarios would be useful.

We will consider the simulation using RCP data. The simulation requires data preparation and organization. This may take a relatively long time to complete. The discussion section may be lengthened to include future scenarios.

Increase Figs. 2, 3, 4 and their legends size by 50 or 100%

We agree to increase the legends size and symbol size to make the figures clear to see.

why are panels b, d, f in Fig. 3 scaled by zero? that makes differences to appear smaller increase legend in Fig. 5

Agreed. We should decrease the axis scale in Fig. 3 to make the difference appear bigger. We will increase the legend in Fig. 5.

increase Fig. 7 and 9, why fig. 9 it has 2 legend bars?

We agree to increase the size of each panel in Fig. 7 and Fig. 9. Fig. 9 represents the carbon accumulation amount during each time slice. The unit is kg C m^{-2} kyr^{-1}. We mistakenly put extra color bar in panel (f). We will delete it.

line 137 "observed water contents drive STM"?, did you mean observed temperatures?

The STM considers soil water content at different depth to simulate the soil temperature. We used the observed soil water content at particular site to drive the STM when parameterizing the model in *Wang, S., Q. Zhuang, Z. Yu, S. Bridgham, and J. K. Keller (2016), Quantifying peat carbon accumulation in Alaska using a process-based biogeochemistry model, J. Geophys. Res. Biogeosci., 121, doi:10.1002/2016JG003452.*. During the regional simulation, we used the simulated soil water content at different depth directly from HM to drive the STM.

lines 235-238 reformulate for clarity

We compared the peatland basal age distribution with the vegetation types during each time slice and found some relationships among them. We will make specific statements on this.

line 293 correct value of C storage

We will change this value to 0.8 kg C m^{-2}.

lines 300-302, 309 reformulate for clarity

We will make the statement clearer and more concise.

line 315 range of what?

The range here is for vegetation carbon storage. We will clarify this.

lines 325 "spots were widely spread" reformulate, "SOC concentration" do you mean SOC storage?

We will change it into “there were fewer spots with low SOC density”. The “SOC concentration” is SOC storage or density for particular pixel.

line 326 reformulate “tundra was taking back area” or similar

We will change it to “tundra area increased” or similar.

line 361 Table 4 is not showing parameters

Agreed. We will change the statement to “due to uncertainties of observation” or similar.

lines 375-377 reformulate for clarity

We will reformulate the sentences as “The pixels with highest SOC density were mainly located in northern coast. Southwestern coast and eastern central also had high carbon storage (>40 kg C m^{-2}), while areas with lowest density (<20 kg C m^{-2}) were in central and western parts.
lines 420 – 460 reformulate for clarity

We will reformulate the discussion part.

line 424 why if p < 0.05 “some certain effects”?

From the result in Wang et al. (2016) that p-value is less than 0.05, we can get the idea that the interaction factor does have some effects on the carbon accumulation rates. We will clarify this.

line 428 “positive effect” of temperature? low temp slowed SOC accumulation, that’s negative effect

Yes, it should be “negative effect” as the cooler condition during the neoglacier period slowed the carbon accumulation. We will clarify it.

line 437 delete “suggesting the warmest climate during HTM” it comes by definition of HTM

Correct. Repeating the definition of HTM can be awkward. We will revise it.

lines 443-448 does not make sense

We will delete this part since it is talking about the uncertainties coming from the climate model (ECBILT) itself, which can be tedious and less focused. We directly used the output of the model.

line 452 what is “stored C in overall in the spatial scale”?

We should have made the sentence clear. We will change it into “Overall, SBP stored lower C than SP”.

line 454 “negative accumulation rate” avoid writing nonsense

We will change it to “with some areas accompanied by C loss”.

lines 485 – 545 reformulate whole section, move results into results, check for repetitions, highlight only most important trends and insights, shorten discussion if nothing much relevant to say

We will follow your and editor's comments to make the revision.

lines 508-519 OK

References – change into the corresponding format of Biogeosciences

We will change all the references into the format of Biogeosciences.

We planned to submit the manuscript to JGR-Biogeoscience at first. In this manuscript, we cited Wang et al. (2016) JGR paper, which was under revision at that moment. We thought it might complicate the editor's decision. Therefore we decided to submit it to Biogeosciences. However, the manuscript has never been submitted to other journals before.