

Interactive comment on “Peatland area and carbon over the past 21 000 years – a global process based model investigation” by Jurek Müller and Fortunat Joos

Anonymous Referee #2

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This manuscript presents a new study using a revised/improved LPX-Bern model to simulate peatland distributions and carbon accumulation dynamics during and since the Last Glacial Maximum. This is an important study that makes significant contributions to understanding peatland dynamics and their critical roles in land biosphere carbon balance and global carbon cycle.

There are several novel aspects of the study. For example, the detailed sensitivity and uncertainty analysis of peatlands during the LGM using PMIP3 models as well as TraCE21k climate simulations is the most extensive analysis yet on LGM peatland accumulation. The conclusion that model-specific simulated climates are important

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for peatland extent and carbon stocks would be very much useful for future peatland-climate analysis on the basis of climate simulation results. Another novel aspect is the explicit considerations and analysis of “old/disappeared/buried” peatlands on land and under ocean in flooded continental shelves, which contributes to a more complete accounting and understanding of global peatland dynamics. The results also show very dynamic nature of peatland coming and going throughout the last 22,000 years, which make great ecological sense but has not been demonstrated previously! The attribution analysis is also novel, which provides insights into changing controls of peatlands distributions and accumulation through time in different regions of the world.

The manuscript is rich with data and ideas. There are many new and significant results from this study. For example, peatlands initiated much earlier in Northern Asia than the available data show, and there is much larger simulated tropical peat carbon storage than the observations, etc. There are possibilities that the authors plan to explore some of these ideas further with more complete explanations in separate manuscripts. But I point out some of these, so authors may want to discuss a little further in this manuscript. I think it would be useful even if the authors point out these and then indicate that we don't really know what is going on (See also below).

Early peatland initiation in Northern Asia: As pointed out in the manuscript, the simulated major increase in peatland initiation is about 3000 years earlier at the beginning of BA than the basal peat age compilation. In particular, the West Siberia Lowland has relatively abundant basal age information. I wonder if the author could explore further about the discrepancy between simulations and observations. Is it simply because that available observations have missed the oldest peats, say in the WSL? Or the model overestimates peats, perhaps due to the criteria used to form peat, even though the TraCE21k simulated climates are not biased? Also, I wonder if the fact that Northern Asia, including the WSL, was not glaciated during the last glaciation has played a role in modulating surface topography and hydrology (through TOPMODEL). Addressing this difference could advance our understanding peatland formation process and its

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history.

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Also, I wonder what cause the sharp decrease in peat area and C stock in North America in the middle of the deglacial major warming event BA (Fig. A1b). Why? According to Fig. A2b, it appears that warm climate, especially shortly after 14 kyr BP, is responsible for negative change in peat area/C storage – dramatic increase in respiration/decomposition, with or without peat drying? It would be interesting to see the underlying data and some further analysis and discussion.

Interactive comment

Likely there are no satisfactory explanations to some of these issues/questions, which is understandable. However, I think it would be useful if the authors can point out these and suggest possible future research opportunities and directions in observational data collections and model improvements. The last paragraph of the manuscript touches on future directions, but it would be useful to the data and model researchers if the authors can expand the last paragraph a bit further – in order to benefit the rich data and ideas generated from this study.

The manuscript is mostly written clearly, but with many minor issues throughout that I have pointed out some of these in the specific comments below. I recommend publication after minor revisions.

I do have a suggestion about the reorganization of a subsection: Subsection 3.2 Peatland during the Last Glacial Maximum 3.2.1 Peatland distribution and carbon storage 3.2.2 Uncertainties and sensitivity to simulated climate input data (I think this would work and look better, as otherwise there is only one sub-subsection 3.2.1 in this subsection: awkward).

Specific comments: Title: change to “....a process-based global model investigation” or “Global peatland area and carbon a process-based model investigation”. Also, considering the efforts using PMIP3 climate simulations to explore LGM peat change, I'd suggest to emphasize LGM in the title. A suggestion: “Global peatland distribution and carbon dynamics during and since the Last Glacial Maximum: a process-based

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Page 1 Line 3: 22,000 years but in the title 21,000 years. Be consistent?

L9: unclear about "non-linear interactions". "Non-linear responses of peatland area/carbon to changes in climate (T and P) and CO₂?"

L13: change "through peatlands" to "by peatlands"? change "includes" to "considers"?

L14: unclear about "peatland area shifts": "shifts in peatlands distributions"?

L21: change "forrested" to "forested"

Page 2 L5: "the last 12,000 years"; change from "ice shields" to "ice sheet"

L9: I'm not sure to emphasize "global warming" from land-use change. I agree it is on that direction, but I'm not sure about the magnitude to global warming due to land use of tropical peatlands. It is different magnitude compared to C accumulation in northern peatlands (500 GtC) in the previous sentence. Rewording.

L13: change "peat" to "peatlands" here, to focus on ecosystems, rather than just a component of it, that is, soil.

L15: change to "picked up"

L18: change to "Congo Basin"

L26: add a comma "," before "and knowledge of the amount. . ."

L34: spell out "DGVM" in the first use. Also, correct the typo "DGMV".

Page 3: L1: change to "spatial"

L21: change "and the current interglacial" to "as well as the current interglacial (Holocene)"?

L25: it would be good to state the age for the LMG here.

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L26: change “runs” to “simulations”?

Page 4 L2: delete “,” after “and peatlands”

L6: change “Sphagnum” to italic

L10: change “Acro-” to “Acrotelm” – change this throughout the manuscript. Also, change to “Carbon flux from the acrotelm to catotelm. . .”

L10: It is unclear how bulk density is used (along with mass balance) to determine acrotelm-to-catotelm carbon flux. Elaborate here. Also, this is the first time “bulk density” is mentioned, so how it is determined in the model.

L11: change to: “acrotelm mass balance, the latter determined by carbon influx. . .”

L12: If this is described elsewhere, please cite reference. Otherwise, present formulations here?

L20-21: change to “treated in the same way as the mineral soils. . .”

Page 5: L1: change to ““seed”” (with quotation marks)?

L3: change to “precipitation over evapotranspiration ratio > 1”

P4: it is unclear what “precipitation-interception” stands for? Change to “precipitation minus interception”, if this is the case. Also, change “tree peat PFTs” to “peatland tree PFTs”

P9: change to “For a peat C stock change from 50 .. to about 45 kg m-2, fpot is reduced. . .”

P12: on line 9, you can kg/m2 “C stock”, but here “C pool”. Be consistent. I think soil scientists call this metric as “Soil C density”.

L14: “fpeat” is not defined. Do you mean “fpot”?

L25: delete “them”

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L27: LGM should be defined earlier, as well as its timing. See comments above. Also, change “runs” to “simulations”, so you don’t have to use the awkward sentence like “LPX runs...are run”.

L28: specify the latitude and longitude in the grid resolution, such as “2.5 latitude x 3.75 longitude”

L31: change “from 1960-1990” to “for the period 1960-1990” or “from 1960 to 1990”

Page 6: L8: spell out PMIP3 here (you did in the Conclusions section) L11: change “dismissed” to “not used”, and to “because of THEIR poor performance”

L19: change to “from 0.37 to 1.7 Mkm²”

Page 7: L2: change to “between 3 and 5 kyr BP”

L14-15: The sentence is unclear. Change to “These differences are due to new modifications/additions/features as described in Sect. 2.1 in the updated model version, LpX v1.4.” Not sure how “after data assimilation (Lienert and Joos, 2018)” fits here. Are these revisions based on data assimilation? If not, how does data assimilation contribute to the revision of LPX?

L16: change “area” to “peatland area”

L21-22: change to “LPX simulates more peat in Alaska and Quebec and less in Western Canada than PEATMAP.”

Page 8: L6: change “Northern” to “northern”, “from 270-604” to “from 270 to 604”

Page 9: Table 1: change “Afrika” to “Africa”

Page 10: L17: change to “Sphagnum” (italic) and “East North America”

L32: change to “these gaps; however, climate anomalies...”

Page 11: Figure 2 caption: -“agreement (as number of models simulated peat in given gridcell) from LGM timeslice simulations from LPX that were forced with different cli-

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mate anomalies from six PMIP3 model as well as TraCE21k simulations" -change to "Dots in (a) and (b) show buried and still active peat deposits..."

Page 12: L10: "from TraCE21k"?

L29: change "in some models" to "in simulated climates of some models"?

Page 13: Figure 3: -caption: change to "... peatland carbon during the LGM (21 kyr BP) timeslice forced with climate anomalies simulated from seven different climate models" -Figure 3 legend: maybe move legend between the 2nd and 3rd panel, so peat C stock would be close to its Y-axis on the right side. -change "Trace21k" to "TraCE21k" throughout?

Page 14: Figure 4 caption: also define PB as Preboreal, or better yet spell out "Holocene" on the figure itself!

Page 15: L4: add "and" before "(iii)"

L5: change "South-East" to "Southeast", to be consistent. Delete "the beginning of"

Page 17: Figure 6: add panel labels a, b, and c on the figure

Page 18: L12: change "seized" to "ceased"

Page 19: L12: "between 8 and 4 kyr BP"

L20: "during the recent millennia", "warrants"

L21: "Southeast Asia", be consistent. There are at least three ways for this in the manuscript: Southeast, South-East, and South East. Perhaps just use "Southeast Asia" throughout.

L32: change to "The so-called old peat carbon pools presented here..." or delete "so-called" L32: When analyzing peat C impact on the global C cycle/budget, you assume that old carbon stored on flooded continental shelves were transferred and buried in marine sediments, rather than released into the atmosphere during flooding

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with rising sea level. Maybe state this assumption. It would be interesting to quantify the proportion of this C pool that has been buried under ocean or released to the atmosphere.

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L34: “their respective pools”

Page 20: Figure 7: add panel labels a, b, c and d on the figure

Page 21: Figure 8: add panel labels a, b, and c on the figure

L4: change to “in-depth”

Interactive comment

Interactive comment on Biogeosciences Discuss., <https://doi.org/10.5194/bg-2020-110>, 2020.

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