All line numbers refer to the original manuscript.

CC1, Paul J. Morris: https://doi.org/10.5194/tc-2022-135-CC1

General remarks

I enjoyed reading this interesting manuscript by Könönen et al., which seeks to fit bioclimatic models to permafrost peatland landforms, and then project those models into the future under two of the four RCP scenarios to examine shrinking climate spaces. The findings agree with other recent studies that strong climate migiation may retain some areas that are climatically suitable for permafrost peatlands by the end of the century, while the failure of climate change mitigation will lead to an almost-complete loss of suitable climate space.

R1: We are pleased to hear that Dr. Morris enjoyed reading our manuscript. Please note that we address all his comments below.

The study is strikingly similar to a paper that my group published earlier this year in Nature Climate Change (Fewster et al., 2022), to the point that much of the method and some of the conclusions are all but identical. Given the timing of the two articles, it appears that the two groups have been working on similar studies simultaneously. The timing is of course inconvenient for the group that publishes second, who find the novelty of their study reduced. Comparisons between the two studies are inevitable.

R2: Yes, it was very unfortunate that two research groups were studying the same theme with comparable methods, without knowing about each other's work. A great chance for collaboration was missed. Even though there are similarities between our data collection and methodology used, there are also differences beyond those mentioned in Morris' comment below. Fewster et al. (2022) used one-versus-all binary logistic regression, whereas we used four different modelling methods generalized linear model (GLM), generalized additive model (GAM), generalized boosting model (GBM) and random forest (RF) and their ensemble to examine potentially complex non-linear relationships between palsa/peat plateau occurrence and environmental variables, and interactions among these variables. Our results are based on 100 iterations which enables prediction uncertainty estimation, and we evaluated our models not only with the cross-validation but also with a separate evaluation data, which was set aside before the model calibration. But like Dr. Morris comments the comparisons between our studies are inevitable, which is why we reflect our results to those of Fewster et al. (2020, 2022).

I am sympethetic to this potentially awkward situation, and I believe there is certainly room in the literature for this new study.In their favour, Könönen et al. have a larger spatial domain than ours, a much finer grid resultion, and a more detailed representation of soil organic carbon as a continuous variable rather than our simple binary peat presence/absence. All of these things add value and novelty to the current study. On the other hand, Könönen et al. omitted RCP2.6, and therefore don't provide an optimistic, "best case" future scenario; and the large increase in spatial domain comprises extremely data-poor regions, leading me to question the validity of the findings there.

R3: We appreciate Dr. Morris' sympathy and encouragement for our study. We were aware of this awkwardness of our timing. However, we considered that including the entire circumpolar permafrost region to the analyses gives important new insights to the field of study, even though the approach has own challenges. Morris made good suggestions in his community comment and our responses (i.e., incorporation of RCP2.6 scenario) appear later in this response letter.

Substantive issues

My main concern is how far the authors have had to extrapolate from extremely sparse observataional data in central and eastern Siberia. This is particularly evident in Fig. 1a, which shows that there are about 20 observations across the whole of this huge area, despite the widespread distribution of modern permafrost, and plenty of peat there too. It is difficult to believe that tehre are so few palsas and plateaus there, and the authors acknowledge later on that more observational work is needed in these areas. However, the consequence for the current study is that the vast majority of observations are in western Siberia, Europe, and North America, meaning that the statistical modelling is in effect a hemispheric extrapolation of a model fitted to specific locations. The paucity of observations in central and eastern Siberia is the main reason we omitted these regions from our own study. It is quite possible that palsas/plateaus in C/E Siberia occupy different climatic envelopes than those elsewhere, but without observational data we can't tell. As stated above, I am sympathetic to the fact that our two groups appear to have been working on similar studies at the same time, and without central and eastern Siberia, the current study loses much of its novelty. Therefore, I recommend that the current authors make it clear early on (in their aims and/or methodological summary) that the modelling in central and eastern Siberia is an extrapolation from models fitted to N America, Europe, and W Siberia; and qualify their findings throughout accordingly
R4: We appreciate the helpful suggestion. The extrapolation of the models was a concern for us also. We will do the suggested and much needed modifications throughout the manuscript to clarify that our results for Central and Eastern Siberia are extrapolations from models fitted to other parts of our research area. Moreover, we would like to make a note on the comment: ‘It is quite possible that palsas/plateaus in C/E Siberia occupy different climatic envelopes than those elsewhere, but without observational data we can't tell.’ We agree on this because there are not enough data to test this hypothesis. On the other hand, preliminary results from regional analyses (results not shown) show that climatic conditions of palsas and peat plateaus do not substantially differ between relatively continental areas in Canada and Western Siberia. Obviously, colder climates are found in Siberia, but no palsa or peat plateau observations are available from these regions. The possible absence of palsas and peat plateaus therein could be due to the continuous extent of permafrost that favors the development of other periglacial landforms, such as ice-wedge polygons and pingos (French, 2017), or thinner peat cover (Seppälä, 1988, 2011; Hugelius et al. 2020).

We will also add a new figure to the manuscript (fig. R1; see below) comparing our binary predictions for the period 1950–2000 with different peatland datasets. According to these comparisons and the used peatland datasets, there are not especially many suitable peatlands in Central and Eastern Siberia. The lack of peatlands within the suitable climate space (fig. R2) indicates that our sparse observational data might not actually underestimate the occurrence of palsas and peat plateaus in the region as much as one could expect. Along the new figure, discussion related to this issue will be added to the manuscript to the result and discussion sections.

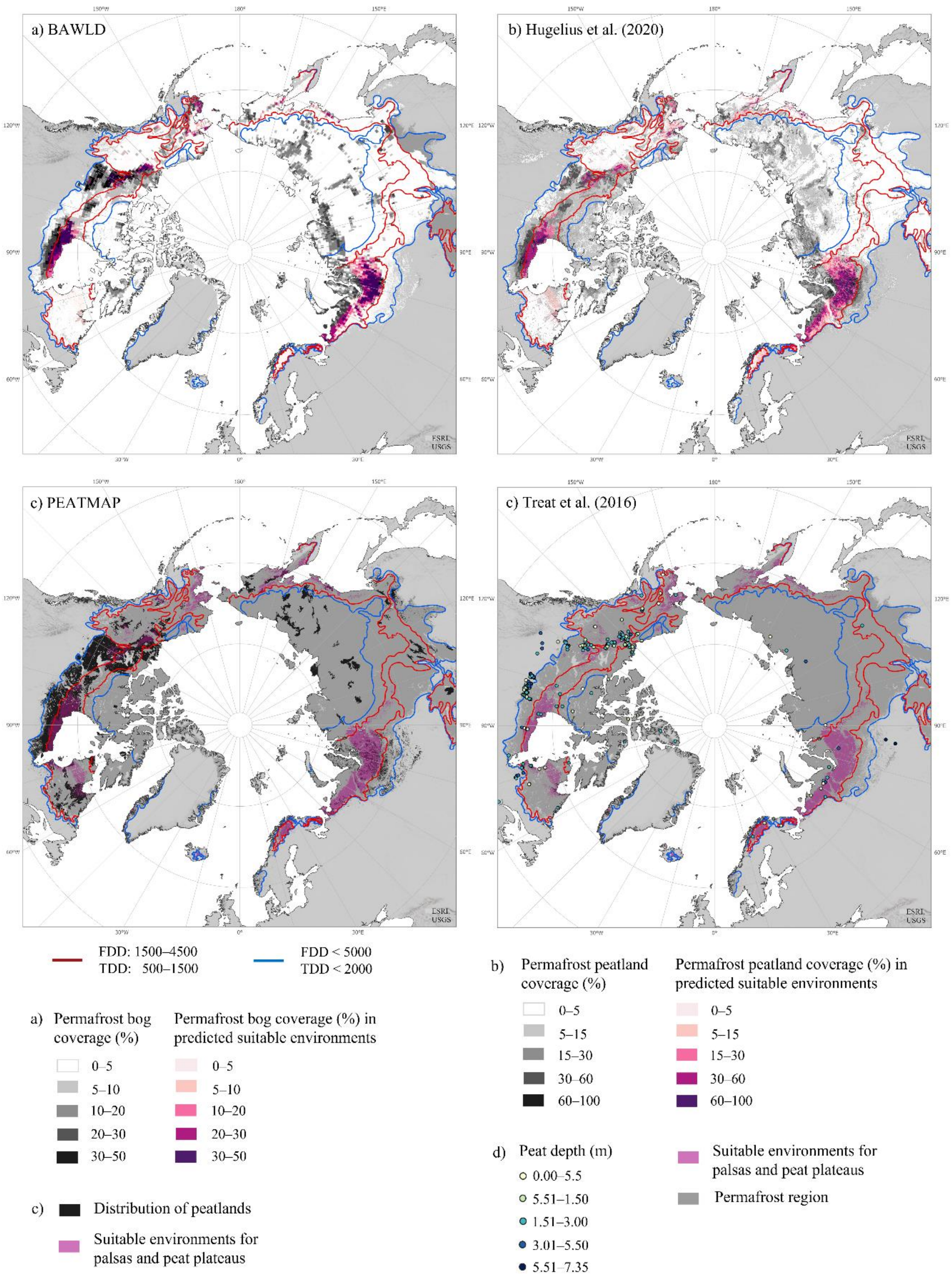

Figure R1: Comparison between the predicted suitable environmental spaces for palsas and peat plateaus (for period 1950–2000) and different peatland datasets; (a) Permafrost bog coverage percent (0–50 %), in each grid cell according to the Boreal–Arctic Wetland and Lake Dataset (BAWLD; Olefeldt et al. 2021), (b) permafrost peatland coverage percent (0–100 %) in dataset produced by Hugelius et al. (2020), (c) distribution of peatlands according to PEATMAP (Xu et al. 2018) and the predicted suitable environments, and (d) peat depth according to Treat et al. (2016a) in point symbols (yellow to blue scale), suitable environments, and permafrost region (Ran et al. 2022; dark gray). The suitable environmental spaces for palsas and peat plateaus are illustrated with pinkish colors whereas areas outside our binary predictions are illustrated with grey scale. Suitable climate spaces (based on FDD and TDD) with two classifications are illustrated in red and blue lines. All datasets are extracted to the permafrost region (Ran et al. 2022).

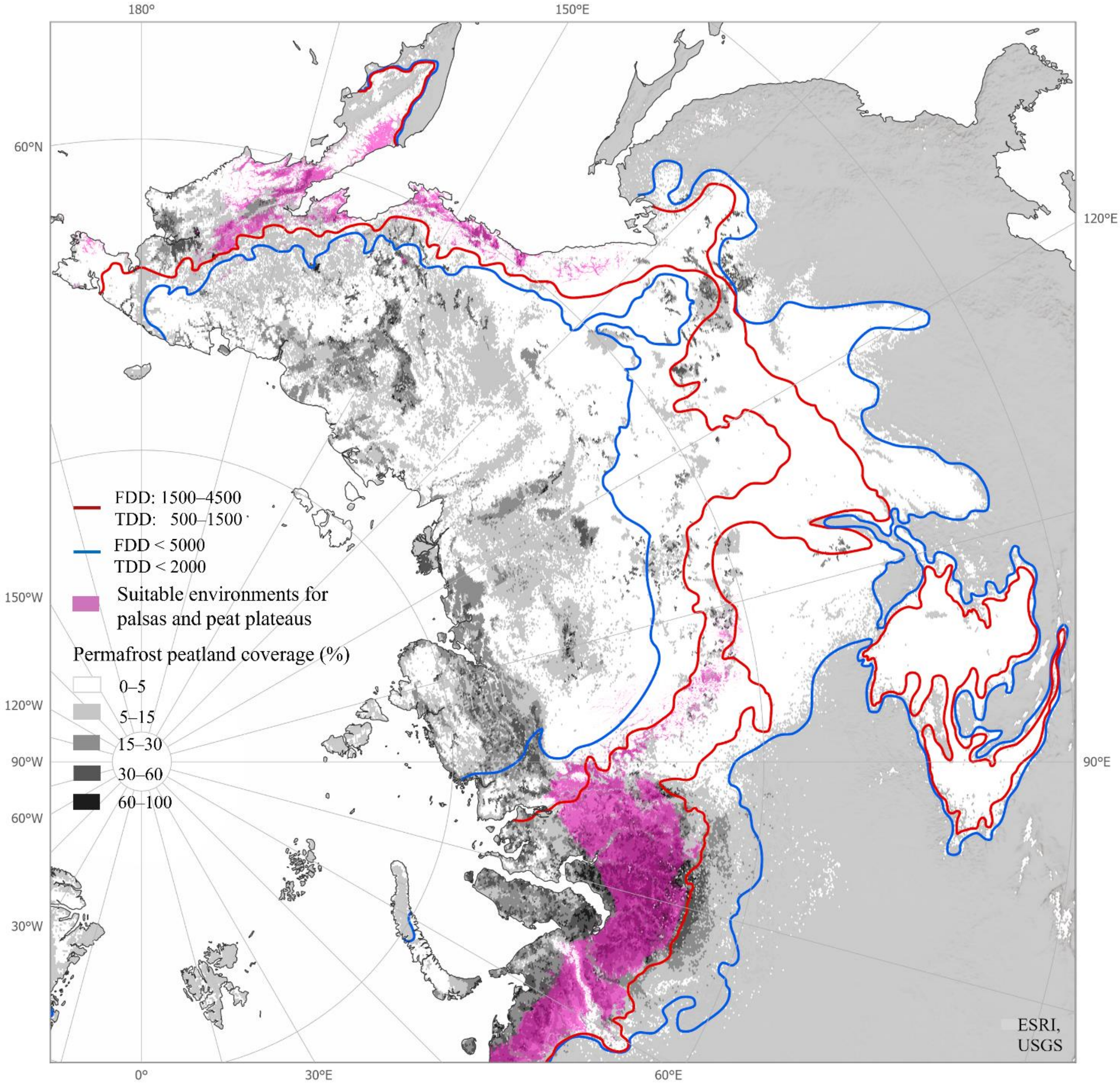

Figure R2: Suitable climate spaces (based on FDD and TDD) with two classifications illustrated are in red and blue lines. In the background suitable environmental spaces for palsas and peat plateaus (period 1950–2000) and permafrost peatland coverage (%) according to Hugelius et al. (2020). All datasets extracted for the permafrost region (Ran et al. 2022).

The authors have used only two of the four RCP scenarios - the pessimistic, worst-case RCP8.5, and the moderately-optimistc RCP4.5. However, it would be valuable to see the other two scenarios, RCP2.6 and 6.0. too. In particular, there may be a big difference from RCP2.6 to RCP4.5. Even in RCP4.5, we can see that the large majority of of the 20th century climate space has gone. We recently showed (Fewster et al., 2022) that the lowest emissions scenario (SSP1 in our case) predicts the preservation of much of the original climate space in western Siberia. A similar finding across the larger study area here would be valuable to know. I recommend that the authors add at least RCP2.6 to their analysis, if not RCP6.0.

R5: This was a great idea on how to improve this study. Originally, we left the RCP2.6 scenario out from the manuscript as we considered it unlikely for this optimistic scenario to be realized taking into account the fast current pace of the climate change. However, after reconsideration and Morris' recommendation we decided to include this lowest emissions scenario to the study. We will add RCP2.6 scenario to our analysis but will leave the RCP6.0 out because we think that it would not have similar added value.

Other than these things, I found the paper to be mainly logical and well-written, clearly and attractively illustrated, and with sound and reproducible methods. The comparison of predictions of shrinking palsas to remotely-sensed images of thermokarst ponds is a clever way to provide some validation.
R6: We thank Dr. Morris for the overall positive comments and important suggestions to improve our manuscript.

Minor and typographical issues

Throughout - overuse of the word "the". I have been through the PDF manuscript and added strikethrough annotation to examples that could be deleted for improved English. Please see attached.
R7: We highly appreciate Dr. Morris' efforts to improve the English of the manuscript. We have checked the attached supplement and will remove unnecessary "the" words from the manuscript.

27 - primarily in regions
R8: Will be corrected: from → in

28 - ...differ mainly in their extent and height...
R9: Will be corrected: by → in

39 - important to global carbon budgets, palsas and peat plateaus
R10: Sentence will be modified accordingly.

46 - classified palsas as critically endangered
R11: We will add the word 'as'

60 - not found in the Southern Hemisphere
R12: Will be corrected: from → in

79-85 - the method description here is almost identical to that by Fewster et al. (2022), which you cite elsewhere. Even to the point of identifying the search terms for nations and Canadian provinces. It would seem appropriate to acknowledge that this is all but the same method.
R13: We will add citation: (see Fewster et al. 2022).

100-101 - in the evaluation set were selected so that they were located at least
R14: We will add another 'were'

101 - crietrion (not criteria; singular, not plural)
R15: Will be corrected to singular

102 - as they were located too close
R16: The word 'were' will be added

117 - were computed separately
R17: Word order will be corrected.

142-3 - jumbled sentence, please reword. I can't follow the intended meaning of this sentenmce, so can't suggest an edit myself.
R18: The sentence will be removed, and its content will reword at the end of the paragraph.

"We performed 100 iterations for each modelling method and built an ensemble from the produced models. Multiple modelling techniques were utilized in order to acknowledge the uncertainties associated with individual modelling methods (see Thuiller et al. 2009) and select the one with the highest performance in the current task. Moreover, the performed 100-fold random sampling of modelling data allowed us to provide uncertainty measures (standard deviation) for the predicted probability values."

153-4 - some justification would be in order here. Why not consider interaction terms? Particularly given that they are included in the random forest model.
R19: We appreciate Dr. Morris' attention to details here. We retained from including interaction terms in GLM and GAM for a couple of reasons. We aimed to keep the models as simple, and hence, as generalizable as possible in belief that this would suite the current task which involved model extrapolation to some regions sparsely represented in the modelling data. That is, we anticipated that fitting potentially complex interactions would have weaker transferability. GBM and RF inherently consider interactions owing to the tree-based model fitting approach where the model fit can be closely controlled with a set of model parameters (such as learning rate, and the number and depth (complexity) of the fitted trees). As such, they are transferable across the study region without a risk of overfitting to the data used in model calibration.

The above-mentioned characteristics of GBM and RF turned out advantageous in the case of circumpolar palsa and peat plateau modelling, but prior to achieving these results we considered it possible that the implementation of regression based GLM and GAM without interaction terms could indeed prove valuable with the task at hand. Whatsoever, the evaluation (Fig. 6) demonstrated them having lower predictive performance compared to GBM and RF. Yet, with the separate evaluation dataset TSS values were only slightly lower and with remarkably low standard deviation which speaks for their generalization ability with the spatially semi-independent evaluation dataset.

192 - remove superfluous comma after "Other".
R20: The comma will be removed.

192 - were found in the Northwest Territories...
R21: Will be corrected: from → in

350 - also affect
R22: Word order will be corrected.

References used in the response letter:

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