All line numbers refer to the original manuscript.

RC2, Anonymous referee: https://tc.copernicus.org/preprints/tc-2022-135#RC2

The manuscript "Environmental spaces for palsas and peat plateaus are disappearing at a circumpolar scale" by Könönen et al. presents statistical modeling of the future distribution of the palsa/peat plateau landform, with the key result that the largest part of todays palsas/peat plateaus will move outside the suitable climate space for some of the future scenarios considered. The study is well-designed and well-written, so I recommend it for publication after revisions.
R1: We thank the reviewer for these positive and encouraging comments. Below we address the raised concerns in detail.

-Introduction: the authors should make an attempt to clarify the terms "peat plateau" and "palsa", or state that they made no clear distinction between the two (since there are many transitional types, for example). In some parts of the text, it appears that the authors do distinguish between them. They for example only refer to palsas in Scandinavia (l.48, and actually continue only using palsa to l. 65), but there are many plateau-like structures in Scandinavia, which published studies have referred to as peat plateaus. They also cite studies claiming that "peat plateaus are only 1m high" (l. 30), but there are much higher plateau-like features in many peatlands with permafrost.
R2: Thank you for these important points. We will add two new sentences to clarify that these two landforms are not clearly distinguishable from each other:

"Palsas and peat plateaus are not clearly distinguishable from each other, and many transitional types are found. Peat plateaus can be considered as a morphological class of palsas, so-called palsa plateaus (e.g., Åhman, 1977; Seppälä, 1988).".

In this study (line 92), peat plateaus were considered as palsa plateaus instead of distinguishing these two landforms from each other. The statement was modified to avoid misunderstandings. We will modify lines 48–65 (and throughout the manuscript) so that both landforms are discussed at the same time without the distinction. We will also add word 'usually' when describing the height of peat plateaus to acknowledge that higher peat plateaus exist.

-L. 84: same here, how do the authors distinguish a "true" palsa?
R3: The term "true palsa" here refers to a peat hummock with a frozen core. Studies and observations of lithalsas (so-called mineral palsas) were excluded from the data as they don't have the necessary peat cover on them, or the peat cover is very thin. The distinction was based on the description of the studied landforms in the utilized literature. For example, if palsas were referred to as lithalsas or mineral palsas they were not included. We will modify the line 84 to make this distinction clearer for the reader.

-L. 87: were high enough resolution images available on Google Earth for all of the sites?
R4: We used both Google Earth and satellite images in ESRI's ArcGIS Pro to verify the landform observations as stated in the manuscript. For some sites better resolution images were available in ArcGIS Pro and vice versa. The resolution of the images between regions varied substantially and some observations had to be left out because of inadequate image resolution.

-L. 123: These data sets can have a poor quality, especially at the resolution needed for the study setup. Please comment on this already in the Methods.
R5: We will revise the text related to the quality issues as proposed.

"The SoilGrids data layers have been produced using a relatively small amount of data from some permafrost regions, especially Central Siberia and High-Arctic Canada, which may affect their accuracy in these regions, especially at finer resolution. We decided to use SoilGrids as alternative soil data were not available in the used (30 arc sec) resolution, and we wanted to include soil variables, especially soil organic carbon (SOC), in our environmental data. Here, the SoilGrid variables at the spatial resolution of 250 meters were aggregated to the 30 arc-second resolution using bilinear interpolation in ArcGIS Pro."

-Eq. 1: shuffled
R6: will be corrected.

-L. 188: it is easier to read if the authors spell out Random Forest (RF) once more at the beginning of the Results section.
R7: We will spell out Random Forest once more as requested.

-Fig. 3: spell out the abbreviations in the figure caption.
R8: Abbreviations will be spelled out in the figure caption.

-L. 237: MAJOR COMMENT: Maybe I have overlooked it, but the authors should clarify if they only consider areas that are in the suitable palsa space now AND in the future as "remaining areas", or if they also count areas that are not suitable now (e.g. too cold in summer), but will become suitable in the future. As shown e.g. in the works of Seppälä, one needs permafrost-free conditions in the vicinity of emerging palsas for this process to work. So areas which today are too cold for palsas to exist may not develop palsa landforms for a long time (or never), even if they move to the suitable space (for example continuous permafrost first needs to thaw, etc.) On the other hand, areas with palsas today will be preserved if they still fall in the suitable space in the future. I think it is worth to make this distinction and possibly present the numbers for both cases. The wording in this section is incoherent, the authors use "remain" and "persist" in some cases, and "could be found" in others.
R9: We thank the reviewer for this important remark. In the caption of figure 4 it was mentioned that our future predictions were extracted for the extent of the suitable environments for the period 1950–2000. So, we did not present any 'new' palsa and peat plateau environments that might develop as there are several uncertainties, as the reviewer points out. As mentioned by the reviewer the development of palsas (and peat plateaus) might require permafrost-free conditions nearby the emerging palsas before the landforms can start to develop. In addition to this, sufficient peat layer is also needed for palsas and peat plateaus to form. Peat accumulation is a slow process and affected also by the climate change. For these reasons we did not consider it plausible that many new suitable environments could form, at least during the 21st century.

To clarify our decision to the reader we will add a sentence:
"We did not consider it plausible to new palsas and peat plateaus to develop during the 21st century and thus the future predictions were restricted to the current extent of the suitable environments."

We will address the exclusion of possible new suitable future conditions in the discussion and modify our wording to be more coherent by using only the word 'persist'.

-Sect. 3.3 The comparison with the thermokarst map is the weakest part of the study, e.g. it is unclear to what extent some of the data sets used by Olefeld et al. may have been similar to the data sets used for this palsa mapping. Furthermore, it is unclear if one should expect a close match or not, given the methods used by Olefeld (i.e. were the specific thermokarst conditions of palsas/peat plateaus accounted for in this work?). I leave it to the authors to decide, but I am not learning anything from this comparison, it more dilutes the very nice results from the previous section with a poorly motivated add-on.

R10: We will clarify our motivation for this comparison in the last paragraph of the section 2.2. Our main purpose for this section was to provide an independent evaluation of our future predictions. Olefeldt et al. (2016) used six variables describing the permafrost zonation, ground ice content, thickness of the sedimentary overburden, ecoregion, and ruggedness of the topography. Same datasets were not utilized in our study, and thus our analyses can be considered as independent.

"We compared our predictions to a circumpolar thermokarst dataset by Olefeldt et al. (2016). The dataset includes different types of thermokarst landscapes, and their areal coverages classified into five classes, ranging from none (0–1 %) to very high (60–100 %). We utilized wetland and lake thermokarst coverages as these types can be assumed to be present in degrading palsa mires (Luoto and Seppälä, 2003; Olefeldt et al., 2016). The purpose of the comparison was to assess the consistency of our future predictions. Palsas and peat plateaus form thermokarst ponds when ice-rich permafrost thaws (e.g., Seppälä 2011). Consequently, regions with high thermokarst coverage can be assumed to indicate degradation of palsas and peat plateaus. Regions predicted to become unsuitable for palsas and peat plateaus in future scenarios should have higher thermokarst coverage than persisting suitable environments."

-L. 308: Extrapolate instead of present?

R11: We will use the suggested wording. The whole manuscript will be modified so that it is clearer for the reader that our results (especially for Central and Eastern Siberia) are extrapolations of models calibrated for Northern Europe, Western Siberia, and North America.

-L. 360: MAJOR COMMENT: this is an extremely important point that needs to be discussed in much more detail. Some of the studies cited, e.g Borge, provide indications that peat plateaus were already degrading more than 50 years ago, so they may have left the suitable climate space already after the end of the Little Ice Age (or in the 1990s, when exactly is unclear and certainly depends on the exact location), but the degradation is slow so that it takes decades or even centuries to complete. However, these areas were still used by the authors for training their model. With the simple analysis and no means of telling which palsa areas are stable and which are degrading already now, I don't think that this can be taken into account, but it is a limitation that should be stated clearly.

R12: We thank the reviewer for this important comment. We agree that there is a need to address this point in the revised manuscript. As the reviewer mentioned there are no simple ways to take this point of view into account in our analysis. For example, we did not have comprehensive information on the 'stage' of palsas (stable/degrading) and had no basis to remove just certain observations. The best that we were able to do here was to use 'a recent' climate period (1950–2000) instead of a current one (e.g., 1991–2020). The recent period presents colder climate than our current climatic conditions and thus resembles better the conditions of the period of palsa/peat plateau formation. More discussion about the issue will be added to the revised manuscript.

Furthermore, given this complexity, I strongly disagree with the statement "support the rapid degradation of the landforms." First, with rates of 1% per year, it will take longer than the 2080 timeframe considered by the authors for the palsas/peat plateaus to actually disappear, in any case several decades. Second, it is very likely that palsas degrading rapidly already now, e.g. in the ones in Scandinavia, will indeed disappear until 2080, but palsas in areas that are still largely stable today might only be pushed just outside the suitable climate envelope and only then start to degrade slowly (similar to the ones in Scandinavia after the LIA). So we might expect palsas and peat plateaus to exist there much longer than 2080, although they are outside the suitable climate envelope.

R13: This is an important point. We will revise the paragraph and add discussion related to this issue as mentioned above (in reply no. R12).

I very much like that the authors use the wording "inside/outside the suitable climate envelope/environmental space" throughout the manuscript and do not refer to their study as a model for palsa degradation. But it is important to clarify and discuss this relationship in much more detail, so this section of the discussion should be extended. In particular, the authors should point out that not all palsas inside the suitable climate envelope are equal, but palsas on the "warm side" of the envelope likely degrade earlier and more rapidly, while the ones on the "cold side" might persist for many more decades

R14: We are glad to hear that the reviewer shared our vision of the best terminology for our predictions. To make this distinction clearer for the readers also, we will add a short discussion about the differences between degradation of palsa and peat plateaus and the changes in suitable environments. As the reviewer pointed out, all palsas and peat plateaus will not degrade at the same pace. More likely palsas in equilibrium with the current climate will persist longer (see Tam et al. 2014) than those in imbalance with it (e.g., Olvmo et al. 2020). We will add discussion related to these "warm" and "cold" palsas and peat plateaus to the discussion section.

References used in the response letter

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