Response RC2: Anonymous

Dear authors,

I very much enjoyed reading your manuscript and think you have done a good job in both setting the question, conducting the research and writing the paper. It was easy to read and I think you have many strong points to raise including the strong effects of VPD, that it is the saturation that varies, the strong link to maximum temperature and what that implies for our possibility to monitor and study the effects of VPD. Moreover you have illustrated that well with a data set of bryophytes.

I will try to be constructive to point out a few things that perhaps could improve the clarity of the paper. In general I think you could take a careful look at the flow of the text to avoid repetition and increase clarity.

Dear reviewer,

We kindly thank you for the positive acceptance of our manuscript, and we are pleased that you enjoyed reading it. Thank you for your constructive approach and helpful feedback. We will do our best to incorporate your suggestions and improve the clarity and fluency of the text.

In the following response, your reviewer's comments are written in standard black font, and our responses are written in blue.

At the same time, we would like to draw your attention to a change we would like to make based on suggestions from reviewer RC1 – we would like to use the average microclimatic values instead of the maximal values. The reasons are discussed in our response to RC1.

Sincerely, on behalf of our author team,

Anna Růžičková

Design of the study.

There is always a trade-off related to the size of the plot to study. A small plot as yours is good to capture the microclimate at one spot, but you will miss a lot of rare species in the landscape. In your case you have a circular plot of 1 meter radius, right? If wo it could be good to spell out. I lack some information on how you selected sites. Was it done using maps and satellite images and getting a coordinate from there? How did you select them in the field? What if a tree was in the plot? Or a big boulder? Did you make any notes on substrate? Substrate composition is often an important driver of species composition of bryophytes. You have an ambitious approach of covering the whole forest landscapes and then perhaps your sample size of 38 plots is a bit low. But you got very interesting results and have an interesting approach so I am still fine with this.

Yes, the species data presented in our manuscript were recorded on a circular plot of 1 meter radius. These plots were selected through stratified-random sampling to capture the main microclimatic gradients within the core zone of the national park (lines 95-96). Specifically, using GIS and detailed digital terrain model, we first divided the core zone into geographical strata defined by the position on the terrain (valley bottoms, lower slopes, upper slopes and ridges) and further separated the slopes into the slopes with predominantly northern and southern orientation. Then, we used GIS algorithms to randomly sample the equal number of locations within each defined strata with the additional conditions that the sampled locations must be separated by at least 300 m.

In the field, we navigated to the selected location with GPS device and placed the center of the plot 1 m to the north from the nearest tree. This tree was later equipped with the HOBO datalogger for air temperature and humidity measurements. Additional condition for plot selection was that the circular

area with a 1 m radius around the plot center must not contain any rocks or big stones in order to reduce the within plot substrate heterogeneity.

We agree that it would be nice to have more plots with complete data (both in situ measured microclimate and sampled bryophytes). However, we think that the 38 plots used in this study is sufficient for our aims. As we described above, the plots were carefully selected through stratified-random sampling. Therefore, they provide representative sample of the environmental variability within the core zone of the national park. The potential effects of within plot substrate heterogeneity were further reduced by the additional criteria for the plot selection (specified above).

Regarding the size of the research plots - we discussed it a lot, because we also collected larger (100 m^2) plots in each measurement site. The smaller (3.14 m^2) plots were always nested in the center of the larger 100 m^2 plot. However, during the bryophyte sampling, we did not make detailed records of the substrate, so we finally decided to based our analyses on the smaller plots (3.14 m^2), mostly because we wanted to minimize the intra-plot substrate variability, which is extremely important for bryophytes. Concerning bryophytes, such selection of relatively small sample plots agrees with the literature (Potter et al., 2013). However, we agree with the reviewer that using small plots can increase the probability of missing some (especially rare) species and potentially also increase the role of stochastic processes. Motivated by this reviewer comment, we repeated the analyses also with the bryophyte community sampled on the larger (100 m^2) plots (see results presented in the table below). The main conclusions of our study are fully supported by these new results, which basically mirror patterns found with the smaller plots. Interestingly, these new results further support our shift from the maximum VPD to mean VPD as the main explanatory variable. To conclude, we still prefer to base our results on smaller plots within the paper, mostly because of the possible issues with the substrate heterogeneity discussed above. However, we are ready to add the result based on larger plots either to the supplementary material or to the main text if the Editor prefer to do so.

		Species composition (db-RDA)		Species richness (GAM)
		Sørensen	**Simpson**	**Number of species**
smaller plots	**VPD max**	10.95 % **	13.52 % **	31.2 % ***
	VPD mean	16.09 % ***	17.15 % ***	32.8 % ***
larger plots	**VPD max**	11.87 % **	10.21 % **	14.4 % ***
	VPD mean	22.14 % ***	13.10 % ***	49.0 % ***

Table of results of db-RDA and GAM models – comparison for smaller and larger research plots

VPD-variability.

I had a bit difficulty in flowing the text of how you calculated VPD-variability and when you talked about the variability over time and over space. And then what you take an average of. I think you need to carefully revise so that a reader understands all of this. For example how can you have a mean value of the standard deviation of the maximum value? And then you talk about range of plot means in Table 1. I am sure you have done it correctly it is just that it become difficult to follow when you have mean and SD values in a day, between days, between plots etc. Especially rows 122-124 I couldn't follow entirely, but revise also in other parts of the text and figure legends so that it is crystal clear when VPD variability consider spatial or temporal aspects for example.

Thank you for bringing this reader's perspective to our attention. We will do our best to make this clear in the text.

Within the paper, we mostly write about spatial VPD variability, which is the most important for the results presented in our paper. However, we agree that the different statistics of the VPD variability presented within the paper can be confusing for the reader. We presented these different statistics in order to describe the different aspects of the data used in our study. In the revision, we will thoroughly revise the text for clarity, and we will focus on the most important aspects of the data variability crucial for our results.

For clarification, we have only presented the variability over time on lines 157-160. On line 158, we talked about range and overall mean of raw measurements performed every 30 minutes. Table 1 reports ranges and means of microclimatic variables (the average daily maxima) used as explanatory variables in our multivariate analyses. We hoped that together, this information should help the readers to create a better picture of the data collected.

Regarding the spatial VPD variability. We express this spatial variability as the standard deviation (SD) of the plot-specific values. The mean value of these SD was calculated in two steps – first we calculated SDs for each individual day within the study period from daily maxima/mean measured at all study plots and then we averaged these daily SDs values over the whole study period. We already described this process on lines 122-124, but we will further revise the text in order to improve the clarity for the reader.

Grouping of the bryophytes.

Species could be grouped in many ways and you have three columns in Tablc C1: taxonomy, Major biome and Eastern limit. It seems in the results that you would like to say something on what is characterizing those that are sensitive to high VPD. However, in the results you have not really analysed the results in such a way and you instead talk about “small liverworts”, “hygrophilous bryophytes”, “suboceanic” and “mesic” species. And in several other places you talk about “azonal” species, which is a term not many readers will understand. Yet in other places you say “regionally rare species”. You have so many terms and none of these categories are in Table C1. And you use words such as “in contrast” but these groups are not contrasts to each other in most cases but just different ways of describing them. The number of species you have is not very large so perhaps it can be difficult to divide them into several group for the analysis and it might be just enough to tell the general statistics on the community which you have done and present the results at the species level as in Figure 5. Then if you want you can exemplify species which are less and more sensitive, but perhaps don’t need to put them into a category. Or select one or two “traits” and do a formal test. Substrate is another category that is often useful for describing bryophyte communities.

Thank you for this insight. You are right that it is difficult to put the studied bryophytes into several clearly defined categories for the formal analyses. We indeed wanted to highlight that the species most sensitive to VPD are the species whose occurrence in the studied area can be seen as unexpected with regard to the regional macroclimate (for such species occurrences we used the term azonal). These species are often species which are typical for more oceanic climates or species which mostly occur in the central European mountains. Joint occurrence of these species in exceptionally low elevation within the studied area always puzzled central European bryologists and nature conservationists. Here we found that i) these species are sensitive to atmospheric VPD, ii) occur predominantly in the sites with low VPD, and iii) therefore low VPD sites serve as their microclimatic refugia within otherwise unsuitable landscape matrix. In the revised paper, we will try to explain these important results more clearly, and we will reduce the number of categories used to refer to these species. Following your suggestions, we will focus more on individual species rather than on somewhat arbitrary defined species groups. The categories provided in Table C1 were meant as an attempt to summarize the distributional ranges of the species studied, but you are right that it was rather confusing since we have not used these categories anywhere else. As you

mentioned, the number of species we have is not very large, so it is difficult to strictly divide them into several groups for analysis. Therefore, we prefer to follow your suggestion and concentrate on the general statistics of the community and present and discuss the results at the species level (Figure 5). We will further unify the terms in the text, and we will discuss the results more on species - rather than group - level.

Detailjed comments:

Sensitivity of bryophytes to high maximum temperatures and high VPD. I think there are more references on this even if they might be more implicit. But for example various studies on forest edge effects on bryophytes could be relevant. Check also Dahlberg et al. 2020 in Environmental and Experimental Botany, who saw some interesting correlations with maximum temperature and distributions. Perhaps you might also be interested in Merinero et al. 2020 in Ecology who used evaporometers to capture the importance of VPD as a driver of bryophtye performans.

Thank you for your literature recommendation. We searched the literature thoroughly, but the studies exploring directly the effects of atmospheric VPD on forest bryophytes are surprisingly rare. Often, the link is indirect and supported by the measurement of the different variables, as in both references you suggested. Nevertheless, we re-read these references and agree that they are relevant for our study, therefore, we will refer to them in the revision.

Figure B1. Would it be good to indicate the 1:1 line in this graph and discuss a bit more on why your line is deviating. But very interesting that you have such a strong relationship!

Thank you for this suggestion. We will include the 1:1 line in Fig. B1 and will discuss the reasons for the overestimation of local VPD (deviation from 1:1 line) with this method.

References

Potter, K. A., Woods, H. A., and Pincebourde, S.: Microclimatic challenges in global change biology., Glob. Change Biol., 19(10), 2932–2939, https://doi.org/10.1111/gcb.12257, 2013.