- **RC1**: , Anonymous Referee #1, 06 Nov 2023

Common points:

The paper aims to model the vegetation development until 2100 in the Fennoscandinavian to Oroarctic environment due to climate change in a high resolution, including the impact of reindeer grazing/trampling and the effects on biodiversity. The aims of the paper fit well to the scopes of the journal.

We thank you for careful reading and many useful comments that will improve the paper.

In my opinion the resolution is not high. High resolution should be 100 m to 10 m. The data presented here have a resolution of 3 km. Furthermore, the study area extends from the boreal forest to the tundra. Therefore, I would suggest adjusting the title.

What high resolution means depends on what field you are working in. In the context of regional climate modelling, as well as large-scale combined climate-vegetation modelling, 3 km represents a higher resolution than in most other studies. However, we agree that you have a point about the scale and will revise. We will also revise the title to emphasize that simulations were done over a large area. New title will be "Kilometre-scale simulations over Fennoscandia reveal a large loss of tundra due to climate change".

The second paragraph of the introduction should be moved to the description of the study area.

We will keep a smaller introduction of the region to introduce the next paragraph. But most of the text will be merged with the first paragraph of the M&M in line with the reviewer comment.

In the last paragraph of the introduction (Line 93 to 100) it could improve the manuscript (structure) if the task and the objectives are clearly stated. The objectives should then be always used in the same order in the other sections of the paper (methods, results, and discussion).

As also the other reviewers have pointed out that task, objective and hypothesis should be clearly stated, we will revise the last section of the introduction. We will add this sentence after "which is particularly important in complex terrain.": "It is important to understand how climate change might affect the vegetation at this scale and for that DVM modelling is needed". In the end of the paragraph we will add "As the only available climate projection at this resolution is a high-emission scenario, the simulated state at the end of the century will provide a message to society of what to expect and plan for if emissions continue to increase. We hypothesize that this state will show extensive changes that will present challenges for forestry, reindeer herding, forestry, tourism and nature conservation.". However, we do not agree that the objectives always should be used in the same order. You can build a good story in the discussion without following the objectives.

I would also suggest being consistent with presenting the results, especially for the evaluation of the modelled data. From my point of view, it would be useful either to use always the mean values for a certain period or the values of single years.

The reason why we have compiled the modelling results for 10-year periods, also when compared to inventoried or satellite-based products for single years, is that the random

nature of the disturbances in LPJ-GUESS otherwise could influence the results and comparisons. We should have explained this and we will add a statement in section 2.5.1.

Please add letters (a, b, c, …) to the single figures in combined figures.

We will add letters in the single figures where appropriate. Though note that we have headings for the columns and lines in which the figures are placed that may be more useful to specify the subfigures for the more complicated figures.

Maybe present the figures addressing the specific sites presented in Figure 1 always in the same order, e.g., from north to south.

We have chosen to present first mountain sites from north to south and then forest sites from north to south and we always use the same order.

I would suggest being consistent with the used units of the resolution or if the resolution is given in degree add the converted unit in brackets.

To be more consistent we will use km as main unit and for data originally in degree grid we will present a rough resolution in km. This is however not straight forward, as at these high latitudes the distance for a degree unit is 2-3 times larger in S-N direction than in W-E, depending on latitude (https://www.nhc.noaa.gov/gccalc.shtml).

Probably move parts of the 4th paragraph (Line 587 to 593) to the conclusion.

As also Leanne suggested to more clearly state the uncertainty in the conclusion, we will move these lines to the conclusions.

Specific points:
39-41: Sentence unclear.

For clarity we will revise the sentence to "For each degree of global average temperature increase the observed increase in Fennoscandia has been estimated to 2-3 degrees (Rantanen et al., 2022), and this relationship persists in future predictions (Ono et al., 2022).".

94: … here use the 3 km-scale climate projections…..

We will revise as suggested.

Figure 1a: The squares and points as well as the fonts should be made more legible.

By changing the tone of the background and colour of the text we will make the figure more legible.

Figure 1: please place the letters indicating the subfigures in the same position.

As there is a top-left inlet figure in b we placed the letter below. We will revise to get the letters in the most consistent way possible.

119-121: This sentence is for me not clear.

We will revise and divide into two sentences "The model simulates the development of cohorts, belonging to different plant functional types (PFTs), when competing for light, nitrogen and water in replicate patches (here set to 15 patches per simulated climate gridcell). Each patch represents an area of 1000 m^2.".

121: 1 km² (please be consistent in using the units).

It is well established that 1 km^2 means one square km, not 1000 square meters. 1000 m^2 is then not 1 km^2 but 0.001 km^2, we still think that it is most appropriate to express it as 1000 m^2 and prefer not to revise. The only place we use km^2 is in line 551, where it is an appropriate unit.

122-124: are the process descriptions related to cycling of water and carbon based on species composition?

Except for the soil, these processes are calculated at cohort level, we will add this information.

134: add the wetlands.

We agree that it is better to also mention the wetland PFTs in this first sentence of 2.2.1 and we will add that.

Table 2: Please specify the species more for each plant functional type, e.g., *Alnus* sp. could be a shrub or a tree. Add typical species for the PFTs C3G, pmoss, and C3G_wet.

We will revise the exemplified species as suggested.

Furthermore, you should remove the species *Vaccinium vitis-idaea* and *Vaccinium myrtillus* from this list as they show no clear habitat preference (occurence in two different PFTs). This could be important if the process descriptions are depending on the species composition.

Given that *V. vitis-idaea* is an evergreen species and *V. myrtillus* is deciduous these species still belong to different functional types for which they are common representative species We feel that these PFTs are sufficiently well distinguished in the model, and do not intend to revise this.

145-147: Please add the information you used for the fine-tuning of some model parameters.

As also pointed out by Leanne and Referee #2, we admit that it is not clearly expressed. We will revise lines 143-147 to "For the IBS plant functional type some parameters were changed according to Gustafsson et al. (2021) in an application for Abisko, Sweden. Their revision was made to reflect the fact that the global IBS PFT in Fennoscandia mainly represents mountain birch (*Betula pubescens* ssp. *tortuosa*). Details of the IBS parameterization are found in Table S2." and add this text to S2 "Using the default parameters, test runs with a sub sample of gridcells showed a substantial underestimation of deciduous broad-leafed forest adjacent to the mountains, where it is

represented by the Shade-Intolerant Broadleaved Summergreen tree plant functional type (IBS) in the simulations, when compared to the satellite-based products (see section 2.5.1). We therefore tested the IBS parameters from Gustafson et al. (2021), who had adjusted them to more specifically represent the small tree mountain birch (*Betula pubescens* ssp. *tortuosa*) and calibrated it to grow and compete as expected for the Abisko area (Gustafson personal communication). Simulations with these parameters on the other hand resulted in a too large extent of deciduous broad-leafed forest and to reduce the competitiveness of IBS the original values related to shade tolerance and turnover were used instead. For the same reason, we also adjusted the alphar and turnover_sap parameters." In Table S2 we will then also add the parameters that were not changed according to Gustafsson and add a column so that there will be "default 4.1", "Gustafsson et al. (2021)" and "used value".

169: Reference for the HCLIM38-ALADIN is missing and when you accessed the data.

We will add reference (Belušić et al., 2020), data access is described in the "Data availability" section.

170: Reference for the HCLIM38-AROME is missing and when you accessed the data.

We will add reference (Belušić et al., 2020), data access is described in the "Data availability" section.

181: Reference for the ALAatARO data is missing and when you accessed the data.

The ALAatARO dataset was produced in this study, which we will additionally clarify in the paper: In line 179 we will revise to "…when only ALADIN data were available, we first produced datasets such that the four…", and in line 181 to "(termed ALAatARO, 1985-2100)".

250-251: Which method was used for aggregating the satellite-based products to the 3 km resolution.

We used dominant class, we will add this information.

311: Please give the percentage for the UA and PA.

Thank you for pointing out this, we realize that this should be more specifically expressed. We will revise to "resulting in poor UA for broad-leaf deciduous shrubs (0.5%) and needle-leaf evergreen shrubs (0.0%), and poor PA for shrub tundra (0.2%).".

319-321: Did you use the average LAI for these periods or was it the change of LAI, PFTs respectively?

It was average, which we will specify.

381-382: "As the classification…." should be moved to the methods part.

We will refer to S5 where it is described instead of the details.

394: from which year is the vector-based map?

We will add the date (2021-09-09), both here and in S1.

472: From my point of view it is not the trend in grazing as the number of animals are constant over time and the authors simulate the grazing effect based on the loss of biomass. For me, if the authors talk about trends in grazing the authors should include the life stock units (LSUs).

We agree. The header will be revised to "Trends in potential reindeer grazing 2000-2100".

516-518: The thawing palsas were never mentioned before in the manuscript.

We will reformulate the sentence to make it clear that we bring up something new.

519: comma is missing after: e.g.,

Comma will be added.

Supplement S3 Line 40: (225 000 – 280 000)?

The missing zero will be added.