

RC2: ['Comment on bg-2023-148'](#), Anonymous Referee #2, 21 Nov 2023

### General comments

**This study focuses on a subject of great scientific importance: changes in vegetation at high latitudes. The work presented is of high quality and based on state-of-the-art data and methods. The figures and the introduction and discussion sections are of good quality and in good shape for publication. The M&M and results sections could benefit from some changes in content and structure (see following paragraphs).**

Thank you for positive words and many useful comments, we will improve the M&A and discussion sections following your more specific comments.

### Specific comments

#### Introduction

The introduction is clear, synthetic, and overall presents a sufficient number of scientific references. It describes the processes taking place in high-latitude regions, in particular the impacts of climate change and reindeer husbandry on the different ecosystems (boreal forest, tree-line and tundra). It presents the implication of vegetation dynamics modeling (DVM) and the added value enabled by scenario climate data at a 3km scale.

One introduction paragraph (line 54-61) should be moved to the Material and Method section, as it describes the study area and interrupts the flow developed in the introduction.

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 as suggested.

In addition, it would be interesting to present the initial hypotheses of the study, particularly with regard to the description made of the causes (societal and climatic) of change in plant communities.

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.”

Finally, it would be interesting to mention the LPJ-Guess model in the paragraph on DVM, in order to highlight its field of application.

We will mention LPJ-GUESS in the paragraph starting at line 78.

## **M&M**

This section is well presented and provides a clear understanding of the data and studies used to complete this scientific production. More detail could be provided on certain paragraphs (see specific comments). More specifically, the choices made regarding data acquisition, interpolation type and parameter tuning must be sufficiently justified or discussed.

A comparative analysis of different climate (RCP) or socio-economic (SSP) scenarios would have been desirable. Thus, the authors of the study are invited to explain this choice of scenario.

With the addition to the last paragraph of the introduction suggested above, we don't think it would be needed to elaborate on the choice of scenario in M&M.

## **Results**

This section provides well the overall results of the study with different type of figures. This section is quite dense and would benefit from structural reshaping, including topic sentences introducing most paragraphs.

We will not revise the general structure of the Results, but we will add introductory sentences to the sections where appropriate.

## **Discussion & Conclusion**

I truly enjoyed reading the Discussion section which adequately explain the results and does not hide the limits of the method. I have very few comments on this section.

Thank you.

## **Technical corrections**

38 « biological and societal significance » What do you mean by biological significance?

We will remove “biological”.

82 « This information does not capture all local variation, especially in areas of complex terrain where altitudinal differences can be strongly underestimated » This sentence would require a reference.

We will add the Lind et al. (2020) reference also to this sentence.

91 « km-scale » Would be more rigorous to refer to 3km-scale throughout the text

The idea behind the term “km-scale” in climate modelling is to distinguish km-scale (implying 1-4 km) from coarser resolutions (>10 km). In other words, “km-scale” stands for the order of magnitude of 1 km (i.e. < 5 km), rather than the specific value of 1 km. In line 91, we will change it to “... first ever climate model projections at 3 km grid spacing...”. We will still use the more general “km-scale” in more general contexts such as in the title and in line 94, and we will explain what the term means in connection to that line.

110 « The study area (shown as altitude from sea level (dark green) to 2000 m a.s.l. (yellow), the six focus “hotspot” areas (shaded squares and black text, see Figure S1 for detailed maps) » Instead of adding the description of symbols and colors in the text, use a legend directly in the figure with color (even for altitude) and symbol. What's more, the names don't appear clearly.

We will add a height legend and revise the colours so that the figure will be more legible.

127 « disturbances representing e.g. devastating pests or wind storms, occur randomly in each patch (return time set to 150 years in the presented simulations) » In natural/semi-natural ecosystem, disturbance does not occur randomly. Some ecosystems are more fire-prone (e.g. fire) depending on the season. You might want to discuss the "150yr return time at random" in the discussion, especially considering its huge significant impact in vegetation dynamics

We will discuss uncertainty related to disturbance return time in the vicinity of lines 605-610 in the discussion

139 « For fractions of land classified as peatland » Include peatland location in Fig. 1.a.

The peatland areas are too small and scattered to be shown in the overview of Figure 1a. The areas are shown in Figures 2, 4 and 6 as the peatland area is not dynamical but prescribed from this “PEATMAP”. But due to the scale they can only be detected in Figure 6.

145 « A fine-tuning of some of the model's parameters was therefore done to get a better match against distribution maps from observations » Your parameter changes seem significant, especially for growing degrees days. Could you explain your choices in more detail? Does LPJ-GUESS present a poor calibration of this PFT in general or for this geographic zone in particular?

As also pointed out Referee #1 and Leanne, 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  $\alpha$  and  $\text{turnover}_{\text{sap}}$  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”.

150 « Grazing/browsing was simulated by removing a fraction of leaf biomass. » Provide a reference to support the assumption that grazing/browsing only/mainly affects leaf biomass. Some could argue that plant survival or growth could also be directly affected.

LPJ-GUESS has only stem, leaf and fine-root compartments, grass PFTs only leaf and fine-roots. We have not found any study of what proportion of the consumed biomass that is twigs/branches. We will acknowledge that we may have underestimated the effect of reindeer browsing in the discussion paragraph starting at line 548, based references that show the height differences of the vegetation between open and enclosure sites. We will also add a comment that there are rather small differences in simulations with or without reindeer presence in section 3.3.1.

200 « The RCP8.5 scenario used was the first dataset produced at this high resolution for the entire region » The first and only one? Please indicate why using this particular scenario and not propose a comparative analysis with Shared Socioeconomic Pathway to get a nuanced vision of vegetation dynamics in the future.

As stated above, we will state already in the introduction that there indeed really was only this scenario available at this resolution.

210 « 5 arc seconds (10 km) » Please use consistent unit for resolution (km preferred)

To be more consistent we will use km as main unit and for data originally in degrees we will present rough resolution in km. It 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>).

211 « had been interpolated to 3 km resolution » What type of interpolation?

“interpolated” is not the appropriate expression here as they were just taken from the relevant 10 km data cell. We will just skip the expression after the parenthesis.

225 « downscale the 50 km data for the 1900-1986 period. After 2051, the 0.5° resolution Lamarque et al. (2011) dataset was used, which is standard for LPJ-GUESS. » How the final resolution of 3km is reached?

The Ndep data were simply at a coarser resolution. We are aware that this could be a potential problem, but we have done a sensitivity test using the coarser 0.5° Ndep data and compared it to simulations using the high-resolution data, finding very small differences in simulated vegetation composition. We will add this information but will not provide specific results.

226 « 0.5° » require consistent unit

To be more consistent we will use km as main unit and for data originally in degrees we will present rough resolution in km. It 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>).

267 « to convert modelled total biomass to above ground biomass we assumed a factor of 0.85 based on earlier estimates » Root:shoot ratios could be very variable for forest tree species. For instance, in (Huttunen et al. 2013) they estimated that for silver birch seedlings, the ratio between BGB and AGB could vary from 0.35 to 1.2 under different conditions and would be around 0.55 without treatment. Even though you consider here adult trees, the approximation of 0.85 should be discussed.

Huttunen, Liisa & Ayres, Matthew & Niemelä, Pekka & Heiska, Susanne & Tegelberg, Riitta & Rousi, Matti & Kellomäki, Seppo. (2013). Interactive effects of defoliation and climate change on compensatory growth of silver birch seedlings. *Silva Fennica*. 47. e964. 10.14214/sf.964.

We will add the range found by Huttunen et al. (2013) to the range by Johansson (2007) when showing uncertainty of the 0.85 value.

299 « Simulated\_LAI = 0.78 × SURFEX\_LAI – 1.99,  $r^2 = 0.59$  » You might consider providing the results with an intercept of 0. In addition, even if an  $r^2$  of 0.59 can be considered satisfactory, you should explain where and why the simulated LAI differs from the SURFEX data.

As there is such a large intercept (-1.99), we don't think it would be useful to show statistics for a regression through zero. We will comment on this large intercept and reasons for the big difference.

340 « Figure 3» Compared to the high quality of the other figures, this one could be reshaped and made more clear

We will make an overhaul of the figure to improve the quality.

381 « As the classification is based on LAI, bare rock was set for LAI 0.01- 0.001 and permanent snow/ice < 0.001, indicating that plants have the potential to grow there » Unclear and might be put in M&M section

Instead of the details given between the commas in the sentence of lines 381-382, we will refer to supplement S5 where it is described: "...based on LAI (see S5) it indicates that plants...".

385 « Figure 5 » This figure is really interesting and well designed, congrats. One thing, to be more rigorous, the 3 rows should be made from equivalent latitude band sample (not 0.2, 0.15 and 0.1 °)

Thank you for the appreciation. Again, the bands should not be equally wide as the number of gridcells per latitude degree is different. Now the area of the bands has an area of 10000, 8500 and 7300 km<sup>2</sup> from north to south. We will make a revision of the figure for consistency.

442 « It should be kept in mind that the data obtained from the Analysis Portal relies on what has been reported by a large community of public and professional naturalists, which means that biases can exist e.g., depending on the specific biological interests of rapporteurs visiting the different areas. » this sentence might be preferably put in Discussion section and more developed. Indeed, this section aim at providing an overview of selected hotspot diversity but in my opinion the method for this purpose should be more discussed.

We will move this statement to the discussion line 533. We think that discussion of the details of methods for collecting this type of data would take too much focus from the main aspects of the article.

478 « Figure 8 » The colour legend might be redefined to better show region with low and high change of consumption. In addition, it could be interesting to plot the relative change (percentage) instead of the absolute one which poorly reflects effect on vegetation.

We will try to find a better colour scheme. To show relative change will not be possible as many grid cells are at zero in present period.

501 « dramatic » This term has a negative connotation, but the consequences of such a change in vegetation are complex and not entirely negative, depending on the process under consideration.

We will change to a more neutral word: “extensive”.

544 « This is because many of the alpine species in the hotspots areas that are not listed today will be threatened as warming continues. » This need a literature reference.

We will add a reference.