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Biogeosciences Discussions

Interactive comment on "Effects of shrub cover increase on the near surface atmosphere in northern Fennoscand" *by* Johanne H. Rydsaa et al.

Anonymous Referee #1

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Rydsaa et al. present an interesting investigation into changes to the near-surface atmosphere resulting from vegetation change, with a particular focus on near-surface temperatures. They use the WRF model to compare simulations where the vegetation extent is (i) based on present day climate distributions, and (ii) relating to a 1K increase in summer temperatures, relative to the current vegetation distribution. The authors also considered the sensitivity of this response to inter-annual variability. Based on the results presented in this manuscript, the authors suggest that tall shrubs are key to a summer warming feedback but that the main impact of shrub expansion is on advancing the onset of snowmelt in the spring, thus inducing a positive feedback to spring temperatures. In terms of inter-annual differences, the authors propose that

their results show that the warm summer-tall shrubs feedback is consistent across warm and cold seasons. They finish by proposing that their findings show "a clear potential for a so-called vegetation-feedback tipping point".

In order for this paper to be acceptable for publication in Biogeosciences, the following major revisions are required:

1. Ideas are not always introduced in a logical manner, and the text is frequently hard to follow. Moreover the writing style needs to be more concise to improve clarity and flow of ideas (See detailed line-by-line comments for examples). It would also be nice to see some hypothesis or specific research questions clearly stated in the introduction and these used to structure the subsequent results and discussion. This would greatly facilitate the overall readability and coherence of the work, but will require some major structural changes to the manuscript to be achieved.

2. Central to this work is the assumption that published climate envelopes for vegetation types in Norway are sufficient to predict changes in future vegetation when mean summer temperatures are 1K warmer. However, the authors show significant discrepancies between the present-day vegetation distribution and that expected from the climate envelopes based on present day climate. This suggests that either (i) the climate envelopes are inappropriate, or (ii) the present-day vegetation is out of equilibrium with the present climate – perhaps due to warming that has already occurred. The former case presents obvious difficulties for the use of these climate envelopes. In the second case, it seems somewhat unrealistic that the vegetation will have had time to adjust to the scenario indicated by the climatic envelopes under 1K warming, given the timeframe over which 1K warmer summer temperatures will be achieved. As it stands, this study is limited in how much can be drawn from the 'future' distribution based on the climatic envelopes associated with a 1K increase. There needs to be significantly more discussion of the limitations of using climatic envelopes and justification of their use.

3. It is stated that only the vegetation distributions are altered and that the simulations are identical in all other respects. This suggests that your model is being forced with present day climate for both the reference and 1K runs, i.e. you are measuring the strength of the vegetation feedback under today's climate. However, of interest is the strength of the vegetation feedback in a 1K warmer climate. To assess this, surely the driving meteorological data need to reflect this 1K warming (and associated changes in winter climate and snow cover)? I suggest that you run a new 1K reference simulation with the present-day vegetation distribution and met data reflecting the 1K warming. This would still allow you to isolate the vegetation feedback, under a more meaningful scenario.

4. The introduction highlights the importance of soil properties in determining the distribution of shrubs and their response to changes in climate, in particular drawing attention to soil moisture content, in addition to mean summer temperatures, as key drivers of shrub expansion. This study explores the effects of increased summer temperatures (by 1K). However, it is not clear that the influence of soil properties is taken into account regarding the perturbed vegetation simulations, although this will surely be an important constraint on future distributions.

Detailed comments

Abstract

P1L11 Specify that you are evaluating the sensitivity of near surface atmosphere / temperatures

P1L12 Specify that these are model experiments

P1L21 Shortwave radiation instead of SW would be clearer

P1L22 "shrub and tree heights, which lower the surface albedo"

P1L28 Be more specific –a role in what?

Introduction

P1 L34-6 Writing style needs to be more concise

P2 L6 You mention biochemical effects here but nowhere else. Can you provide some references for this opening sentence?

P2 L7-8 The increase in radiation absorption is due to the decrease in surface albedo –please structure the sentence to reflect this.

P2 L12 "influence the melt and sublimation" this sentence is quite vague –can you specify what this influence is (i.e. does it enhance or reduce melting/sublimation)

P2L15-16 Provide a reference for this.

P2 L16 Missing punctuation.

P2 L21 "speed the melting season" –this is unclear, do you mean that the onset of melting is advanced or that the melting season is shorter and more intense?

P2 L24-39 Provide more information regarding the climate scenarios these vegetation increases related to (i.e. how many degrees increase in temperature) –this will provide better context for your own study

P3 L4 coupled "with" not "to"

P3 L9-12 Please provide a reference(s) to support/illustrate this

P3 L31 "Also based on dendroecological observations in northern Scandinavia" is misleading as the study discussed just previously (Myers-Smith 2015) was based on data from across the circumpolar region, not just northern Scandinavia.

P4 L 6-7 This spatial resolution cannot resolve "fine scale features of vegetation change", which will be occurring on much smaller scales than the model grid size

P4 L12-18 This paragraph could be clearer in its presentation of the main aims of the study. In the methodology you state that differences between seasons are of particular

interest, but this is not mentioned in this paragraph. You should list the hypotheses that are tested in the manuscript here (this will also help provide a structure to your discussion section, relating yours results to the research questions).

Methodology

P4 L22-24 This needs to be explained more clearly, i.e. how do the vegetation change simulations differ from one another

P4 L36 Requires references to said studies

P6 L10-11 "Alterations in the atmosphere results from the biophysical changes related to the applied vegetation perturbations alone" –does this mean that in simulations where the vegetation is prescribed based on a 1k increase in summer temperature, you do not adjust the forcing met data to reflect this?

P6 L19-23 This is not clear

P6 L19 The authors define vegetation categories according to "empirically derived climatic vegetation zones" –they cite Bakkestuen et al 2008 who develop a model for vegetation variation in Norway. It is not clear during the methodology section whether the "empirically derived climatic vegetation zones" are from Bakkestuen et al. 2008 or are derived by the authors.

P7 L4 Should be "e.g. see"

P7 L23 Specify the increase in JJA 2 m temperatures applied

P7 L34 I'm not sure what you mean here

P7 L36-38 Shouldn't the forcing met data reflect the temperature increase in the Veg1K simulation?

Results

P8 L2-3 This should be explained properly in the methodology

P8 L8-10 Refer to table 2 here

P8 L25 Remove "also"

P8 L27 Refer to specific plots, e.g. using lettered plots

P8 L35 Reference to Fig. 7 not Fig. 6

P9 L4 Reference to Fig. 4 not Fig. 3

P9 L14 "These areas" –do you mean areas with low alpine shrub expansion?

P9 L22-23 "... the small albedo decrease associated with the low-alpine shrub increase. The areas with taller shrubs and trees on the other hand, are characterised by a decrease in snow cover throughout the spring and summer seasons due to a stronger albedo decrease (Fig. S4)" –I can't see how this figure specifically shows the different albedo effects associated with these vegetation types (i.e. low-alpine shrub vs. tall shrub and tree)

P9 L27 Add parenthesis

P9 L29-30 "The increased SH mainly acts to heat the lower atmosphere within the boundary layer, while the LH is also released above the PBL height" –it's not clear where this result comes from

P9 L37-39 The figures you refer to do not show the results you present in the manuscript text here (net not incoming SW and LW)

P10 L3 You refer to "increased shrub cover", do you also mean increased tree cover here too? Later on in this paragraph you refer to "vegetation changes" and on L38 you talk about "increased shrub and tree cover" –are you using these three phrases interchangeably or do you mean something different in these instances? It is not clear. Also, please specify which simulation these results are from (I presume Veg0K – RefVeg).

P10 L 5-6 It is not clear from just looking at Fig. 7 that the low cloud cover increase is

predominantly occurring over areas of vegetation change –you should at least refer to the bottom panel in Fig. 1 that shows this or include it again in the empty plot of Fig. 7 for easy reference.

P10 L8 Provide p value

P10 L13-14 “This indicates”. If the only thing that you changed between the two simulations was the vegetation cover, then surely then all the precipitation change must be attributable to this? What else would have caused it if all other variables were kept constant?

P10 L15-18 What do you mean by “summarized”? Looking at Table 2, the 2.2% increase is the averaged change over all areas with vegetation changes and over both cold and warm summer seasons. You only provide the warm spring increase in precipitation (1.1%), why not the change averaged over both warm and cold seasons in this case? This is not consistent with your presentation of the summer result. The 1.4% increase in snow and ice appears to be from the cold summer season (looking at Table 2), why did you select this specific value? Per Table 2 this is not a statistically significant finding, yet the p value you present in this paragraph is (p = 3.19 x 10-9).

P10 L20-25 Be clear that you are discussing the RefVeg simulations here

P10 L 22 “and a 3.1K warmer 2 m temperature, on average.” Looking at Table 2, the difference seems to be 2.97K ?

P10 L27-28 Be clear that you are discussing the RefVeg simulations here

P10 L28 Be more specific –how many days earlier?

P10 L39 Spatial pattern of snow cover shown by Fig. S3 not the spatial pattern of snow depth

P11 L11 Please indicate the subplots of interest here, e.g. Fig. 10 c & d

P11 L21-26 The temperature values presented here do not match those given in Table

2. I presume this is because the Table values are means over areas with vegetation change only whereas in this paragraph you are presenting values for the entire model domain –is this correct? It is not clear why you are not consistent here, particularly as for precipitation you refer to Table 2 rather than continue with giving whole-domain values.

P11 L 36-38 If snow conditions are important then surely you need to take into account that temperature increases during the winter months are projected to be much greater than 1K in your Veg1K simulations.

P12 L2-4 This would benefit from a figure illustrating this change in the vegetation, i.e. such as in the bottom row of Fig. 1

P12 L11-12 This is confusing as both vegetation simulations (Veg0K and Veg1K) represent a “future” scenario? Or at least, Veg0K does not reflect the present-day vegetation distribution but the distribution that one would expect given our present-day climate.

P12 L14-16 The second sentence (“Therefore average spring season heating is therefore strongest in areas with the tallest vegetation”) does not logically follow on from the sentence preceding it. Also, over-use of “therefore”.

P12 L16-18 But what about the spread of temperatures. So, the highest temperature is found in Summer but in Fig 12 it looks as though this is very localised and that during the Spring more of the domain experiences higher temperatures.

P12 L20 Why is this not included in the supplementary material?

P12 L28 Start your discussion off with a summary of your major findings in the order they were presented as hypotheses in the methods section.

P13 L 17-19 Needs re-wording

P13 L21 The authors don’t change the greenness factor of each grid cell between the simulations, this seems strange as you would expect a ‘greening’ effect with the 1K

increase?

P13 L30 "...areas with increased tall vegetation"

P13 L31 "...related to increased low shrub cover..."

P13 L32 "enhanced" rather than "added". What is the balance between these two factors during the spring season?

P13 L 36 What do you mean by "despite the snow masking effect in winter"? Also, you did not analyse winter months in this study. The final part of this sentence doesn't make sense: "the deciduous nature of the northward expanding shrubs and trees in this study, which is based on what is observed in the study region"

P13 L38-40 They haven't allowed for expansion of needle leaved trees –is this reasonable?

P14 L18 Clarify that you are talking about changes in SW and 2 m temperature, i.e. a reduction in early summer

P14 L21 Remove "also"

P14 L26 "we note that they observed a substantially larger response in soils temperatures than was shown in our results"

P14 L36-37 Can you provide the equivalent percentage shrub increases for your simulations to aid comparison with the studies discussed here?

P15 L1 "The response of shrub expansion" –this doesn't make sense; the response of what to shrub expansion?

P15 L2-3 More moderate than what?

P15 L6 Remove "were related to" and change to "are occupied by"

P15 L18 Change 0.04 to 0.05 as per Table 2

P15 L14 "we find" This is the first time a time lag is mentioned. What sort of time-lag –provide an estimate.

P15 L33 Remove "have"

P15 L34 Change "in evaluating" to "to evaluate"

P15 L35 Remove "have"

P16 L12 You stated in your results that this increased snow cover was due to "increased snow fall in the cold season and possibly the increased shading effect of the shrubs" whereas here you are implying it is entirely down to shrub expansion –this seems to be a contradiction.

P16 L35-36 Repetition of P15 L31-33

Figures

Figure 1. The following changes would improve the clarity of this figure:

Labelling sub-plots (e.g. a, b, c, d) would be beneficial for clearer linking between the text and the figure (this comment applies for further figures also).

The temperature limits shown by the contour lines are unclear.

The axis labelling of the fourth subplot is slightly inconsistent with the others.

Why does the vegetation classification change in the final subplot? For instance in the top panels, Tall shrubs are 0.5-2m whereas shrubs of this height are classed as Low alpine shrubs in the bottom panel.

It would be helpful to see a subplot like the one at the bottom of this figure for the other vegetation perturbation, i.e. Veg1K – RefVeg. Why have you not included this?

Figure 2. You have shown temperatures in degrees Celsius here but throughout the manuscript you refer to temperature changes in Kelvin, this should be kept consistent.

Figure 3. If you re-ordered your figures so that figures 2 and 3 precede Figure 1, this would make Figure 1 clearer as it reflects the order that you present the related concepts in the manuscript text.

Figure 5. Refer to Fig. 4 not Fig. 3

Figure 6. This Figure is too small and trying to show too much, which makes it unclear and difficult to extract the key information.

Why did you use that particular cross section?

It is hard to see the stippled lines

What is the difference between the inset scale and the main figure scale? Why are they not consistent?

Figure 7. The middle row of figures would be easier to interpret if the scales were the same.

Not clear from the figure caption which simulation we are looking at (i.e. Veg0k – RefVeg)

Figure 8. On the right plot, label the two seasons as 'warm' and 'cold' or 'RefVegwarm' and 'RefVegcold' instead of the year, as this is how you refer to them elsewhere in the manuscript.

The title of the left plot is too long and so is hard to read where it overlaps the left axis labels.

Figure 11. In the all other figures showing anomaly distributions across the domain, you state that the figure is "only showing significant results at the 95% confidence level" –why do you not do that here?

Figure 12. Inconsistent use of "2 M" and "2m" throughout figures in the manuscript

Specify that these are inter-seasonal means

Table 2. Responses are presented inconsistently: Why are precipitation, snowfall and low cloud coverage changes shown as percentages whereas the actual values are given for the other variables? Why is the mean value for RefVeg MAM Low cloud coverage 0.31 when the mean values for the warm and cold years are 0.29 and 0.29? (this applies to other values presented in the table) Why are you only averaging over areas with vegetation changes? Cloud cover and precipitation effects might not be limited to the atmosphere directly above the vegetation change for instance.

Reference list

P20L1-12 Duplication of reference: Myers-Smith et al. 2015a appears to be the same paper as Myers-Smith et al. 2015b

Supplementary material

Figure S1. Consistent scales would be better

Figure S5. In the text preceding this figure, it is not clear why "(Veg0K-RefVeg)" is included at the end.

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