Referee #1

This paper studies the biochemical and biophysical effects of afforestation in Europe. Usually when the local effects of de-/afforestation are studied this is done with regional climate models without the possibility to study the effects of changing CO2 levels. In this study the 'standard' runs are complimented by results from a radiative transfer model, which enables also an estimate of the biochemical effects. For anyone working with these kinds of questions or simulations this is a welcome contribution since LUCAS type simulations raise the issue of the relationship between biochemical and biophysical effects, and since local biophysical effects of land-cover changes are often neglected in scenario runs. There is a need for estimates of the relative importance of biophysical and biochemical effects.

Thus, this is an interesting contribution that suits well with the scope of ESD. I have, however some comments that I would like to raise before publication. If any of my comments builds on misunderstandings from my side, I apologise beforehand. But it misunderstandings arise from unclear writings in the paper, see that as a reason to rephrase.
- We thank the reviewer for the assessment and the helpful comments on our manuscript. Detailed answers to the comments can be found below. The changes in the revised manuscript have been implemented with tracked changes.

Major comments

1) My first comment is on how CO2 levels are treated. If I understand it correctly the reduction of CO2 builds on a land-cover change from grass to forest. This would mean that the change in CO2 is maximised. The GRASS and FOREST simulations do, however, use present day CO2 levels, which means that they are not consistent with the CO2 levels. In the CARBON simulation, the CO2 level is reduced according to the afforestation. To be consequent, shouldn't the CO2 level in GRASS be increased according to de deforestation from present land cover to grass? Since roughly half of the European land area is covered by forests today, the effect of CO2 decrease should only be half of what you simulate here. I see the point of the FOREST and CARBON simulations, but with this set up you maximise the biophysical effect, but downplay the biochemical effect. The difference in CO2 levels between GRASS and CARBON should be larger, and thus should the temperature difference. The temperature differences seen in e.g. figs 2c and 2d are anyway larger than what we have seen over the last 200 years (PI to present CO2 levels). The conclusion still holds, I suppose, but I think it would be fair if you made it more clear that you only sample a part of the biochemical effect. It is probably more important that all simulations are driven by ERA data which use present day CO2, which adds to this problem.
- Thank you very much for this comment. The reviewer is right, the CO2 concentrations in GRASS are underestimated, but this does not mean that the biogeochemical effects are downplayed in our study. In the CARBON scenario, we calculated how much CO2 would be removed from the atmosphere if a continent completely covered by grassland (GRASS) would be completely afforested (FOREST) (see lines 123-130). Now, there are two possible ways to calculate the resulting reduction in the CO2 concentrations for this CO2 removal in CARBON. First, subtract the amount of removed CO2 from the present-day CO2 concentrations, which are used in GRASS and FOREST. This would enable a consistent analysis of all three simulations. However, as you correctly mentioned, these present-day CO2 levels are not consistent with the applied land cover scenarios and are underestimated in the case of GRASS. Therefore, a second option would be to calculate, in a first step, the amount of CO2 that would be released from transforming the actual European land cover into a continent covered with grassland and add this amount of CO2 to the present-day concentrations. Then, in a second step, the amount of removed CO2 by an afforested continent would be subtracted from the adapted (higher) CO2 level of a GRASS continent. In this way, the CO2 levels of GRASS and CARBON would be consistent.

However, for both options, the total amount of CO_2 that would be removed from the atmosphere would be the same and thus, also the biogeochemical effects and the resulting temperature differences. The only difference would be that the resulting CO_2 concentration would be higher for option 2, since the CO_2 removal would have started from a higher CO_2 level. But following this reasoning the total effects would be the same.
Therefore, we chose option 1, since this procedure allows us to consistently compare the GRASS, the FOREST and the CARBON simulation with each other and relate the biogeophysical effects of afforestation (FOREST-GRASS) with the biogeochemical effects (CARBON-FOREST).
In order to make our reasoning clearer, we added the following statement to section 2.2:
'Thus, an idealized Europe-wide afforestation, starting from a continent entirely covered with grassland, would have reduced the global CO_2 concentrations at the beginning of our simulation period from 347 ppm in 1986 to pre-industrial levels. This global CO_2 concentration is then implemented in the CARBON simulation. Differences in the CO_2 concentrations between a grassland continent and historic CO_2 concentrations are not considered, in order to enable a direct comparison of the CARBON simulation with the GRASS and FOREST runs, and thus, a consistent decomposition of biogeophysical and biogeochemical effects of afforestation.' (lines 150-156).

2) Secondly, I have some problems with the presentation of the results. You describe quite complex interactions, and they need to be explained clearly. I have read the manuscript thoroughly a few times now, and I still don't understand all interactions and feedbacks. Since you don't explain the results so much in Discussions I think you should try to do it more in Results. Section 3.1.2 sometimes kind of tries to explain and sometimes not. For example, why is Ts reduced in summer with afforestation, and why does DLR increase across most of Europe in winter? I think it should be possible for you to do this.

Another problem is that the figures are referenced in the following order in section 3.2: 4a, 5a, 6a, 6b, 4b, 5b, 4c, 6d, 4d (5c, 5d and 6c are not referred to at all). As a reader you are thrown back and forth between figures. This tells me that it's either a problem with the structure of the text or with the composition of the figures. I would like to suggest that you first describe figure 4 completely, and then in order use figs 5 & 6 to explain figure 4. I believe that would be easier to follow, and perhaps also easier to write.
- Thanks for this suggestion. We agree that we could have explained processes in more detail in some parts of the text. Therefore, we restructured the result section of the manuscript. We decided to describe the seasonal changes of the surface temperatures with afforestation (formerly Fig. 5) and their physical reasons (formerly Fig. 6) in an own section (now named section 3.1.2), before we explain the effects on the longwave radiation balance (now named section 3.1.3). These changes in Ts are essential to understand the changes in the longwave radiation balance and should thus be explained beforehand. The former Fig. 5 is therefore now renamed in Fig. 3 and the former Fig. 6 is renamed in Fig. 4. In order to avoid references to not discussed graphs, this new Fig. 4 is additionally restructured. We think that these changes in the structure of the manuscript, make the description of the complex interrelations and feedbacks with afforestation easier to understand. For instance, we are confident that the explanation of the reasons for the increased DLR in winter is now better emphasized:
'Warmer Ts in winter (Fig. 3a) increase the longwave radiation emitted from the surface (except of IP where Ts is reduced). As a result, more longwave radiation can be absorbed by the atmosphere and reemitted as DLR to the surface. This positive feedback on the DLR is amplified by a generally warmer Ta, which is caused by the increased radiative energy input in winter. In addition, Qa is increased in Europe, because of the higher evapotranspiration rates of forests in comparison to grasslands (Fig. 4a). Both, warmer Ta and higher Qa have a reinforcing effect on DLR (positive yellow and green bars). Thus, DLR is enhanced in winter with afforestation although the CO_2 concentrations are reduced.' (lines 269-276).

Furthermore, we extended section 3.1.3 (former section 3.1.2) in order to make the linkage between the CCLM-VEG3D results and the BUGSrad simulations clearer (see minor comment to L196-204). The missing explanation of the reduced surface temperatures in summer is now also included in the new section 3.1.2:

'In summer, forests are able to efficiently transform the radiative energy input at the surface into increased latent heat (Fig. 4b) and sensible heat fluxes, due to their higher surface roughness, higher biomass and deeper root system in comparison to grasslands. Thus, more turbulent energy is removed from the vegetation surface and transported into the atmosphere than for grasslands (Fig. 4c), with the consequence that all over Europe Ts is reduced in summer with afforestation (Fig. 3b; Burakowski et al., 2018; Breil et al., 2020).' (lines 221-226).

Minor comments

L38: What do you mean by 'positive' here? If you mean 'beneficial', I think you should avoid words expressing values. If you mean 'enhancing' I guess that's wrong because the effect is negative (decreasing)?

- We replaced 'positive' with favorable.

L61: 'land use forms'. Forest is not a form of land use. I think you should use 'natural land covers'.

- We replaced 'natural land use forms' with 'natural land covers', according to your suggestion. Thanks.

L63: Do you really mean 'climate benefit'? I think climate effect is more appropriate.

- We replaced 'climate benefit' with 'climate effect', according to your suggestion. Thanks.

L83-84: First, are you meaning 'positive /.../ impact'? Should it be negative since CO_2 is reduced? Second, is the biochemical effect really impacting the greenhouse effect or is it rather impacting temperature. I'm not sure what is correct.

- We replaced 'positive' with favorable. Furthermore, in order to avoid confusion about the term 'greenhouse effect', we decided to not use it anymore in the text and replaced it mainly with the term 'longwave radiation balance' throughout the whole manuscript.

L113-115. Is this the decrease in CO_2 that you get if the biomass goes from all grass to all forest? It could be stated more clearly. It would also mean that there are inconsistencies in the assumptions of CO_2 levels (see major comment 1).

- Thanks for this hint. However, since it is stated in the following sentence/paragraph that 'the whole European continent is afforested, starting from a continent entirely covered with grassland' (line 123-124), we refrain from changing the statement here. But we further highlighted the transition from grassland to forest in lines (150-152):

Regarding the inconsistencies in CO_2 levels, please see our response to comment 1.

L144: I think it would be good to again mention that this is the CO_2 reduction you get if you go from all grass to all forest. And somewhere you should also give the present day CO_2 amount used in the GRASS and FOREST simulations.

- We added the following statement to highlight the transition from grassland to forest and to mention the used CO_2 level for calculating the reduction in the CO_2 concentration with afforestation: 'Thus, an idealized Europe-wide afforestation, starting from a continent entirely covered with grassland, would have reduced the global CO_2 concentrations at the beginning of our simulation period from 347 ppm in 1986 to pre-industrial levels.' (line150-152).

L180: I wonder if there is a way to describe this as 'local biochemical' effects, since you don't capture the full effect of CO_2 changes. Think about that.

- Thanks for this suggestion. We now name it 'regional biogeophysical effects in Europe (lines 189-190).

L180-185: I think it would be good to add some numbers here to support the reader. From figure 2 it's difficult to see if the change in temperature is 1 or 5 K.

- we added numbers and extended the text in the following way:

'For instance, the biogeochemical effects of afforestation (CARBON-FOREST) lead to a reduction of the mean annual Ts of about -0.06 K in Scandinavia and -0.03 K at the Iberian Peninsula, while the biogeophysical effects (FOREST-GRASS) result in a mean warming of 1.06 K in Scandinavia and a mean cooling of -0.77 K at the Iberian Peninsula. The differences between CARBON and GRASS (Fig. 2d), which can be considered as the total effect of afforestation, since both biogeochemical and biogeophysical processes are taken into account, are consequently mainly caused by biogeophysical processes and of the same magnitude as the differences between FOREST and GRASS (1.0 K in Scandinavia and -0.8 K at the Iberian Peninsula).' (lines 197-204).

L189-193: I agree that the biophysical effect is probably stronger than the biochemical effect, but we can't know the full extent of CO_2 changes since all simulations are driven by the same ERA run, and since the CO_2 change is not fully consistent with the land-cover change (if I understand it correctly). Therefore I wonder if it is correct to speak of idealised reduction of the global CO_2 levels. You could question both 'global' and 'idealised'.

- We thank the reviewer for this comment. However, we prefer to continue calling it 'an idealized reduction of the global CO_2 levels'. The calculation of the CO_2 concentrations is based on global CO_2 emissions and global carbon inventories. Thus, the afforestation of a European continent covered by grassland would result in that global removal of CO_2 from the atmosphere that we calculated, based on which the reduction of the global CO_2 concentrations can be derived (see response to major comment 1). But we can call this only an idealized CO_2 reduction, since several aspects of the global carbon budget are simplified in our calculation (e.g. the assumption of an equilibrium on centennial timescales or the fact that ongoing fossil fuel emissions are neglected, see the discussion in section 4). The real carbon sequestration potential of afforestation should consequently be lower and the reduction in global CO_2 concentrations should thus be smaller.

Moreover, we are well aware that indirect CO_2 feedbacks are not considered in our regional climate model approach. This constraint of our approach is therefore also discussed in section 4. But to call it, for instance, a 'regional' reduction or equivalent, would not be adequate for our approach. This is why we like to keep the term 'idealized global reduction'.

L197: 'winter' (and later summer). Somewhere you should state how you define winter and summer.

- As winter we defined the period December to February (DJF), as summer we defined the period June to August (JJA). This is now clearly mentioned in the manuscript (lines 210 and 212).

L196-204: This section is somewhat unsatisfying. You present you results, you don't explain or discuss them, but you give some hints on whether the results are expected. It's confusing to read because I don't know if it's just a presentation of results or if I also should understand them. It's fine if you don't want to discuss the results here, but then it would maybe be good to write something like 'results are discussed further in section X' or 'to understand this further we ran BUGSrad', and save statements about the counterintuitiveness of the results to that part.

- We agree with the reviewer, the sole description of the results in figure 3 without explaining them can leave the reader of the manuscript a bit puzzled. Therefore, according to your suggestion, we included a statement at the end of this section, pointing out that the BUGSrad simulations are carried out in order to better understand the results presented in figure 3:

'In order to be able to explain these spatial longwave radiation patterns, DLR and OLR are additionally simulated with the offline radiative transfer model BUGSrad. By means of a linearization of these BUGSrad simulations, the respective contributions of biogeophysical (changes in the surface temperatures, atmospheric temperatures and atmospheric water vapor concentrations) and biogeochemical (reduced CO_2 concentrations) processes with afforestation on the longwave radiation balance can be decomposed.' (lines 238-243).

L241: Why is Ts reduced? Can you explain?

- The reviewer is right, we have missed to explicitly explain this. The explanation is now included the revised manuscript, as follows:

'In summer, forests are able to efficiently transform the radiative energy input at the surface into increased latent (Fig. 4b) and sensible heat fluxes, due to their higher surface roughness, higher biomass and deeper root system in comparison to grasslands. Thus, more turbulent energy is removed from the vegetation surface and transported into the atmosphere than for grasslands (Fig. 4c), with the consequence that Ts is reduced in summer with afforestation (Burakowski et al., 2018; Breil et al., 2020).' (lines 221-226).

L268: Maybe I just misunderstand this, but is the greenhouse effect strictly the same as the longwave radiation balance? The greenhouse effect occur when greenhouse gases prevent some heat from escaping directly to space. As I understand this the changes in longwave radiation here is because of changes in Ts. Therefore I wonder if you could talk of a weakening of the greenhouse effect. Please explain if I didn't get this right, it's tricky to know what the radiation balance actually is here.

- In order to avoid confusion about the term 'greenhouse effect', we decided to not use it anymore in the text and replaced it mainly with the term 'longwave radiation balance' throughout the whole manuscript.

L273: It would be good to clearly state that what you mean is SR – LR. To compare is not necessarily subtract.

- We rephrased the sentence:

'With this aim, the net longwave radiation leaving the earth system is subtracted from the net shortwave radiation input into the system' (lines 315-317).

L274-276: I'm curious to know how clouds could change the shortwave radiation balance. Changes in evaporation and moisture could lead to changes in cloud cover. Did you look at that?

- We only considered clear-sky situations in our analyses, because in the case of a cloud cover, the longwave radiation balance would be completely dominated by cloud effects. The biogeochemical effects on the CO_2 concentrations are in such cases negligible. Therefore, the focus of our study is not on cloud-radiation interactions.

'Only clear-sky situations (daily mean cloud fraction < 20%) are considered, in order to exclude interfering influences of clouds on the longwave radiation balance' (lines 171-172).

But we noted in our analyses that afforestation generally increases the cloud cover over Scandinavia. In winter, this reduction in incoming solar radiation is however outperformed by the lower albedo of forests (snow masking effect), with the consequence that the radiative energy input is also on cloudy days increased with afforestation. In summer, a slight reduction of the net shortwave radiation is simulated. For more details, please see the publication of Davin et al., (2020).

L277: 'energy budget' Thus far you have used 'energy balance'. It's good to be consequent, and I think 'energy balance' is more intuitive. If you decide to change, there are some other occurrences of budget further down, that also should be changed.

- We replaced 'budget' with 'balance' throughout the manuscript.

L280-290: 'positive TOA energy budget' Figure 7 only shows that TOA-CARBON is larger than TOA-GRASS. This does not necessarily mean that it is positive. Please rephrase.

- We replaced 'positive' with 'increased' and 'negative' with 'decreased' throughout the manuscript.

L333-334: I don't understand this. If you change the amount of greenhouse gases in the atmosphere the temperature will change because the Earth's radiative balance change. In addition to that there are feedbacks or secondary effects. It seems a bit extreme to state that this is of no importance. How could changes in CO_2 concentrations affect snow and ice if not via temperature changes?

- We agree with the reviewer that a change in the CO_2 concentrations modifies the radiative energy balance and thus changes also the temperatures. But this effect is not strong enough to explain the strong temperature changes during the last century. However, the CO_2 induced temperature changes lead for instance to changes in snow and ice cover (as mentioned by the reviewer), which then affect the shortwave radiation balance. And these secondary shortwave radiation effects amplify the direct CO_2 effects, resulting in the observed temperature changes. In order to make this clearer, we rephrased the paragraph as follows:

'However, the results of our simulations are in line with recent studies providing evidence that the temperature effect of changing CO_2 concentrations is not mainly caused by direct changes in the longwave radiation balance, but by changes in the shortwave radiation balance, which are indirectly induced by changes in global CO_2 climate feedbacks, e.g. ice-albedo feedback associated with changes in the snow and ice cover (e.g., Donohoe et al., 2014).' (lines 375-379).

L337 'boundary conditions too warm' Too warm in FOREST and CARBON, but too cold in GRASS because the CO_2 levels should be higher than present day if all land cover was grass.

- please see our response to major comment 1.

L362: I think it would be good to include some lines about the robustness of your results in the discussion. As you already know from e.g. Davin et al. (2020) and Breil et al. (2020) the response to land-cover changes can be quite different across models, especially in summer. How general or model specific would you say that your results are? I'm not asking you to make a model comparison, but I think it's good to mention that other models would give other results.

- We agree and added the following statement to the discussion:

'However, all derived results are model dependent and are therefore associated with uncertainties. For instance, the study of Davin et al., (2020) showed that the response of different RCMs to afforestation can be quite different for some climatological quantities like evapotranspiration. For T_s, conversely, afforestation effects are very consistent across the models in Europe. In winter, afforestation generally leads to warmer temperatures, due to the snow masking effect of trees (Davin et al., 2020). In summer, increased turbulent heat fluxes into the atmosphere are consistently simulated with afforestation, generally resulting in a reduction of T_s in the models (Breil et al., 2020). Thus, the presented temperature responses are in good agreement with other modeling results. This is also the case for the simulated net shortwave radiation all over the year in Europe (Davin et al., 2020). Since T_s is according to the BUGSrad analysis the most relevant biogeophysical quantity for the net longwave radiation and thus, in combination with the net shortwave radiation, also for the TOA energy balance, this gives us confidence that our model results are robust.' (lines 406-417).

L376: 'changes in Ts have a considerable impact on the magnitude of the greenhouse effect' What do you mean by this, and what do you mean with 'greenhouse effect'? The magnitude of the greenhouse effect is not as such a function of local Ts.

- In order to avoid confusion about the term 'greenhouse effect', we decided to not use it anymore in the text and replaced it mainly with the term 'longwave radiation balance' throughout the whole manuscript.

L380: 'clear evidence' Given the uncertainties and methods used I think this is a bit strong message.

- We removed the word 'clear' from the statement

Figs 2,3, 5-8: Please add numbers to the colourbar and preferably also discrete colours. I can't tell if the difference in fig 2 is 1 or 5 K, or 20 or 40 W/m2 in fig 3, for example. Also, it's not wrong to add e.g. OLR or DJF to the figure heads to make things easier.

- We added numbers to the colour bar and extended the headers of the figures according to the reviewers' suggestions. However, we would like to avoid using discrete colour classes in our figures.

We tested it and saw that such a kind of data aggregation would lead to a distorted picture of the relevant processes. For instance, particularly in the case of small differences (e.g. the value is near zero as in Fig. 2b), an aggregation into discrete classes has the consequence that certain effects are stronger pronounced than they really are. Therefore, we tried to draw the classes near zero in white. But this had the consequence that small effects are wiped away and not any more visible. Therefore, we would like to further use a continuous colour scale and hope that the additional numbers at the colour bars and inside the text (see lines 197-204) facilitate the interpretation of the figures.

L630-631: This is a highly confusing caption. I think it could be split. '... a) differences in OLR between CARBON and GRASS; differences in Ts between b) CARBON and FOREST, c) ...
- we changed it according to your suggestion.

L655: 'T' -> 'Ta' beside the yellow box
- is corrected

Typos

L348: extent -> extend
- is corrected

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Referee #2

This study used regional climate model to simulate the biogeochemical (change in atmospheric CO_2) and biogeophysical (change in land surface characteristics) effects of afforestation over the whole Europe continent. The authors found that the biogeophysical effect dominates biogeochemical effect in regulating surface temperature, and idealized afforestation would lead to a net warming over Europe. This study focused on the analysis of longwave radiation budget change due to afforestation, and found that changes of temperature and water vapor due to biogeophysical effect play an important role in the regional greenhouse effect. I have the following comments:

- We thank the reviewer for the assessment and the helpful comments on our manuscript. Detailed answers to the comments can be found below. The changes in the revised manuscript have been implemented with tracked changes.

Lines 79-81: This description is not accurate. For example, the modeling study of Bala et al. (2007) considered the complex biogeophysical effects including changes in longwave radiation, but just did not focus on the longwave radiation budget.

- We thank the reviewer for pointing this out. It was not our intention to state that longwave radiation processes are not included in these studies. We just rather wanted to emphasize that the effects of the biogeochemically induced CO_2 reduction and of the biogeophysically induced albedo changes are generally highlighted in the studies. Therefore, the sentence was modified as follows:

'In general, studies mainly emphasize the effects of the biogeochemically induced CO_2 reduction and the biogeophysically induced changes in the albedo (Claussen et al., 2001; Bala et al, 2007).' (lines 80-82).

Line 110: Please elaborate a bit on how the spun-up simulation is performed.

- We extended the description of the RCM simulation with the following statement about the spin-up procedure:

'For this spin-up, CCLM-VEG3D was again driven with ERA-Interim reanalyses for the period 1979-1985, whereby the same model setup was used as for the period 1986-2015. The simulated conditions in the soil and in the atmosphere at the end of the spin-up period were then used as initial conditions in the long-term simulation' (lines 111-114).

Lines 114-115: When the reduced CO_2 concentration is applied to FOREST and GRASS simulations, is CO_2-induced climate change feedback considered?

- In our study, we analyze the effects of an idealized afforestation on the regional longwave radiation balance in Europe by means of Regional Climate Model simulations. In these simulations, fixed boundary conditions are used, which means that CO_2 induced global feedbacks cannot be considered. This is now explicitly mentioned in section 2.2:

'Differences in the CO_2 concentrations between a grassland continent and historic CO_2 concentrations are not considered, in order to enable a direct comparison of the CARBON simulation with the GRASS and FOREST runs, and thus, a consistent decomposition of biogeophysical and biogeochemical effects of afforestation. As a consequence, the CO_2 induced global climate feedbacks are not taken into account.' (lines (153-157).

Additionally, we discuss the effects of the missing global CO_2 feedbacks on the simulation results extensively in section 4:

'Based on the above, we can assume that an idealized reduction of the global CO_2 concentrations to pre-industrial conditions by a regional afforestation would have a global cooling effect, due to the global climate feedbacks described above. A consideration of such colder global climate conditions in our experiment would of course have certain implications on the biogeophysical processes in our modeling domain. For instance, driving the CARBON simulation with generally colder boundary conditions would enhance snowfall during winter in Europe. The snow masking effect would consequently be increased and more solar radiation would be absorbed than with present-day

boundary conditions. As a result, the TOA energy balance would be further enhanced in winter. This process is known to be the reason for the general warming effect of afforestation in the high latitudes (e.g. Claussen et al., 2001; Bonan, 2008). Furthermore, more snow accumulation in winter would extend the melting phase in spring and increase the differences in absorbed solar radiation between CARBON and GRASS. Since an increased net shortwave radiation in spring (Fig. 8) is already an important factor for the increased TOA energy balance with afforestation particularly in Scandinavia, the total warming would be intensified.
In addition, the impact of wind sheer on the turbulent heat exchange is getting stronger for colder atmospheric conditions, since buoyance becomes smaller (e.g. Breil et al., 2021). That means that the impact of the surface roughness on Ts also becomes stronger. Since the surface roughness of forests is higher than of grasslands, the summertime cooling effect of afforestation on Ts (Fig. 3b) would be increased and emitted longwave radiation would be further reduced. Therefore, the consideration of global climate feedbacks in our modeling approach and thus, a forcing with colder boundary conditions, would even intensify the increased TOA energy balance and the warming effect of afforestation in Europe. An idealized reduction of the global CO2 concentrations to pre-industrial levels by afforestation would consequently not actually cool the regional climate in Europe to pre-industrial conditions, as the regionally increased TOA energy balance would counteract the global effect.' (lines 382-405).

Line 147: How about climate change induced by CO2 change? It seems the atmospheric boundary condition does not change with CO2 change here. This issue should be discussed in detail.
- Please see our response to your above comment.

Lines 271-272: '…whether afforestation has in general a warming or a cooling effect on the regional climate in Europe. In order to investigate that, the energy balance at the top of the atmosphere (TOA) is analyzed'. It should be noted that regional climate change also depends on lateral heat transport.
- Thanks for this hint. We rephrased the sentence as follows:
'Since the regional climate conditions in Europe depend decisively both on the lateral heat transport and on the radiative energy input, the energy balance at the top of the atmosphere (TOA) is analyzed to quantify the impact of the latter.' (lines 313-315).

Lines 332-335: The interpretation of the finding of Donohoe et al. (2014) is not right, and actually does not apply to the lack of CO2-induced feedback here.
- The wording of this paragraph was unfortunately misleading. Donohoe et al., (2014) show that the temperature effect of changes in the CO2 concentrations is not mainly caused by direct changes in the longwave radiation balance, but by indirect changes in the shortwave radiation balance. Changes in the longwave radiation balance just set temperature changes into motion, but the main changes in the energy budget of the climate system are caused by indirect climate feedbacks, e.g. ice-albedo feedback associated with changes in the snow and ice cover, which lead to changes in the shortwave radiation balance. However, such feedbacks are not considered in our RCM approach, since fixed boundary conditions are used. This is the reason why only a small temperature effect of a CO2 reduction to pre-industrial levels is simulated in our experiment, much smaller that one could expect from such a strong CO2 reduction. Therefore, we can conclude that our boundary conditions are too warm. In order to clarify this, the paragraph is rephrased in the following way:
'However, the results of our simulations are in line with recent studies providing evidence that the temperature effect of changing CO2 concentrations is not mainly caused by direct changes in the longwave radiation balance, but by changes in the shortwave radiation balance, which are indirectly induced by changes in global CO2 climate feedbacks, e.g. ice-albedo feedback associated with changes in the snow and ice cover (e.g., Donohoe et al., 2014). Since such feedbacks are not included in our experiment, we have to conclude that the driving boundary conditions of our simulations are too warm.' (lines 375-381).