

Earth Syst. Dynam. Discuss., referee comment RC1
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Comment on esd-2022-51

Anonymous Referee #1

Referee comment on "The response of the regional longwave radiation balance and climate system in Europe to an idealized afforestation experiment" by Marcus Breil et al., Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2022-51-RC1>, 2023

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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 if misunderstandings arise from unclear writings in the paper, see that as a reason to rephrase.

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.

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 T_s 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.

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)?

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

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

L83-84: First, are you meaning 'positive /.../ impact'? Should it be negative since CO₂ 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.

L113-115. Is this the decrease in CO₂ 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 CO₂ levels (see major comment 1).

L144: I think it would be good to again mention that this is the CO₂ reduction you get if you go from all grass to all forest. And somewhere you should also give the present day CO₂ amount used in the GRASS and FOREST simulations.

L180: I wonder if there is a way to describe this as 'local biochemical' effects, since you don't capture the full effect of CO₂ changes. Think about that.

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.

L189-193: I agree that the biophysical effect is probably stronger than the biochemical effect, but we can't know the full extent of CO₂ changes since all simulations are driven by the same ERA run, and since the CO₂ 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 CO₂ levels. You could question both 'global' and 'idealised'.

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

L196-204: This section is somewhat unsatisfying. You present your 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.

L241: Why is T_s reduced? Can you explain?

L268: Maybe I just misunderstand this, but is the greenhouse effect strictly the same as the longwave radiation balance? The greenhouse effect occurs 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 T_s . 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.

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

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?

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.

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.

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 changes. 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?

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.

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.

L376: 'changes in T_s 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 T_s .

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

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/m^2 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.

L630-631: This is a highly confusing caption. I think it could be split. '... a) differences in OLR between CARBON and GRASS; differences in T_s between b) CARBON and FOREST, c)

...

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

Typos

L348: extent -> extend

References

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