

Biogeosciences Discuss., referee comment RC1
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Comment on bg-2022-227

Anonymous Referee #1

Referee comment on "A comparison of the climate and carbon cycle effects of carbon removal by afforestation and an equivalent reduction in fossil fuel emissions" by Koramanghat Unnikrishnan Jayakrishnan and Govindasamy Bala, Biogeosciences Discuss., <https://doi.org/10.5194/bg-2022-227-RC1>, 2022

Review of the manuscript

"A comparison of the climate and carbon cycle effects of carbon removal by Afforestation and an equivalent reduction in Fossil fuel emissions"

by

Jayakrishnan & Bala

for

Biogeosciences

General remarks

In this study, the climate effects of two different methods to reduce atmospheric CO₂ concentrations, namely afforestation and reduced CO₂ emissions, are analyzed. For this

purpose, long-term climate simulations with an Earth System Model of intermediate complexity are performed. In a first step, reference simulations are performed for three different climate change scenarios. Subsequently, the three simulations are repeated, but with an afforested land mass, where forests replace agricultural areas wherever forest can naturally grow. In a last experiment, the different amounts of CO₂ that would have been removed by these afforestation runs are finally implemented in the three scenario runs, but without afforestation.

Results show that CO₂ reductions caused by reduced CO₂ emissions lead to a stronger temperature reduction than CO₂ reductions caused by afforestation, because of the lower surface albedo of forests and the resulting increase in absorbed solar radiation. In addition, the results of the study indicate that the climate benefit of afforestation depends on the background climate and is less pronounced in a warmer climate.

The manuscript is timely, clearly structured and its topic fits to the scope of Biogeosciences. However, there are some issues which need to be addressed by the authors before the manuscript is ready for publication.

Major Comments:

- The whole manuscript is written like a research paper and some aspects are succinctly formulated. In some cases, presented results are tried to be shortly explained in only one sentence, but without success (see point 2 and minor comments). More detailed explanations would therefore be good for the manuscript and increase its comprehensibility. For instance, the additional text in the supplement should be integrated in the manuscript. Some of the supplement figures (e.g. S6, S7, S16, S17) should also be included.
- The explanation for the dependency of the cooling effect of reduced CO₂ concentrations on the climate change scenario is too short. I understand that, in a scenario with a generally high CO₂ concentration, even a larger removal of CO₂ has a smaller cooling effect, since already for such a reduced CO₂ concentration some kind of saturation effect takes place. However, the CO₂ cooling effect is comparable in SSP2 and SSP3, although the CO₂ concentrations are quite high in SSP3. Is there a critical point in the CO₂ concentrations which is not yet reached in SSP3? In addition, the albedo warming effect is in SSP3 almost as strong as in SSP5, although the CO₂ cooling effect is in SSP3 much stronger. This might be related to biogeophysical feedbacks (e.g. changes in cloud cover etc.), which take place in SSP5 but not in SSP3. It would be nice if the authors would discuss this.
- In order to be able to understand all these processes, more information about the model are required and how the complex interactions between the land surface and the atmosphere are considered in the model. By the way, what is the spatial resolution of the model?
- The dependency of a positive climate effect of afforestation on the background climate

is from my point of view the second important message of this study, beside the counteracting albedo effect. This finding is new, at least for me. Therefore, this point should be stronger emphasized and its reasons should be discussed in more detail, and not only be mentioned in one sentence (line 293).

Minor Comments:

Line 185: mean global land surface albedo

Line 229: the warming, caused by the albedo effect of forests!?

Line 244: Please replace the comma with a dot after "(Table S1)"

Line 254: Please explain this buffering effect in more detail? Isn't this reduced ocean carbon uptake a result of the increased temperatures?!

Line 289: warming effect caused by a reduced albedo?!