Ref.: MS. bg-2022-317 Biogeosciences Reconciling different approaches to quantifying land surface temperature impacts of afforestation using satellite observations

Reviewer#1

I would like to clarify my original comment:

1) Taking the timing of de-/forestation as an example, if the change happened in the different years of the two periods of 2002–2004 (t1) and 2010–2014 (t2) (L277), changes in 2002 and 2010 would produce a larger temperature change compared to changes in 2004 and 2014, depending on whether the change signals lasted full three years or just the last year.

Here I provide an example to show the impact of the timing of the land cover change (figure attached). Suppose LST for land type A is 10 and for land type B is 20. A land cover change happened in a year in the second period (2010-2014). When it happened in 2014 (the last year of period 2), the LST change between the mean LST of the two periods would be 2, and when it happened in 2010 (the first year of period 2), the LST change would be 10.

A	B	C	D	E	F	G	H	I	J	K	L
	2002	2003	2004	2010	2011	2012	2013	2014	mean_2002_2004	mean_2010_	LST_change
change in 2014	10	10	10	10	10	10	10	20	10	12	2
change in 2010	10	10	10	20	20	20	20	20	10	20	10

Thanks for the clarification on this point by the reviewer. We provide further explanations on this issue and have made according changes in the revised manuscript.

We understand the case provided by the reviewer and agree that the timing of the land cover change can influence the quantified LST changes by our approach, i.e., by averaging the LST for the several years of our starting and end period and looking at their differences. But we also argue that the magnitude of such influences depends on the type of the land cover change concerned. Deforestation typically involves rapid land-use transitions, and the resulting temperature effects are almost instant (Liu et al., 2018). Here, the instantaneous LST change

at the annual time scale provided by the reviewer represents more likely a deforestation process. In this case we agree that our time-averaging approach will cause the error in the quantified ΔLST as shown in the example provided by the reviewer.

In contrast, afforestation often involves the succession of forests from a sparse canopy to a closed canopy until the newly established forest can be reliably observed by satellite. Accordingly, the biophysical effect will follow the same pattern until it saturates in the closed-canopy forest (please refer to the Figure R1 in our previous responses to the reviewers' comments). Indeed, observation studies show that closed dense-canopy old forests can exert greater cooling effect than the open-canopy young forests (Zhang et al., 2021; Windisch et al., 2021). Hence, given the gradual nature of the afforestation effect on LST, when we quantify the afforestation effect by comparing the time-averaging LST before and after afforestation, the influence of the specific 'timing of afforestation' is expected to be small.

Following the explanation above, the effect of 'timing of land cover change' has been clarified in Lines 586–601 in our revised manuscript: "Differences between the actual and potential temperature effects can also arise from the influences of both the timing of the afforestation and the time length elapsed following afforestation. However, such influences are expected to be small in our study. We argue that such influences should be more pronounced in the case of deforestation than afforestation. The temperature effect caused by deforestation is considered to be instant (Liu et al., 2018). As a result, if deforestation occurred in one specific year of our starting time window (i.e., 2002–2004), using the time-averaging LST over the whole time window to represent the LST before deforestation will greatly bias the quantified ΔT. In contrast, afforestation-driven surface temperature change can only gradually increase with forest development. The LST effect depends on different forest development stages and is expected to saturate only when the forest canopy stabilizes

(Zhang et al., 2021; Windisch et al., 2021). Observation studies show that closed dense-canopy old forests can exert greater cooling effect than the open-canopy young forests (Zhang et al., 2021; Windisch et al., 2021). Hence, given the gradual nature of the afforestation effect on LST, when we quantify the afforestation effect by comparing the time-averaging LST before and after afforestation, the influence of the specific 'timing of afforestation' is expected to be small."

2) The comparison of methods for potential and actual impacts is based on scenario of afforestation, I wonder if the conclusions can be generalized to deforestation or other the land cover change impact?

We believe in principle both our methods and conclusions should be applicable to deforestation and other land cover change impacts. However, larger uncertainty may arise as we explained in our response to Comment #1 by the reviewer, that the "timing of the land cover change" plays a role in the quantified biophysical impacts by approach, especially for the scenario in which instant temperature effects by land cover conversions expected, such as deforestation. Hence, we limited our conclusion to the scenario of afforestation, which is also within the scope of this study.

References

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