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

Reviewer#2

General consideration:

The biophysical effects of deforestation/afforestation have drawn a lot of attention in the past few years. However, the results are not very consistent among different studies using different products and methods. The authors revealed the methodological differences among different studies and summarized them into one actual and two potential temperature effects. They also used afforestation in China as a test case to quantify the differences in biophysical effects using the three approaches and verify their hypotheses. The manuscript is well-structured, and the results are clearly represented. I would recommend the publication of this manuscript after minor revisions.

Some minor comments: Language needs to be further polished throughout the text. Some long sentences are difficult to understand.

We thank Reviewer#2 for the positive comments which allow us to improve our manuscript. Please find below our detailed responses to the review comments, with original comments in black and our responses in blue.

Specific comments:

1. L30, "and that it … explained", Not clear.

To avoid any potential confusion, we will modify the sentence as "The magnitude of ΔT_a increases with the fraction of the pixel actually afforested (F_{aff}) and F_{aff} explained 89% of the variation in ΔT_a."

2. In Methods, need to clarify how gridded effects were aggregated into the country mean for

comparison among the three approaches, because different LC/LST data may have different coverage. How is the overlapped region representative for the whole country?

We verified the representativeness of our research samples by examining the distributions of the temperature effects from original pixels and research pixels (i.e., spatial overlapped samples of different approaches). Fig. R1 shows that 17.5% of original samples for actual effects were retained for further analysis and preserved the same mean value (-0.07 K); while 20.2% of original samples for potential effects, with the mean value (-0.64 K) being close to the mean value of all samples (-0.42 K). The results of the original samples are similar to that of the research samples in the Manuscript (MS) (Fig. 5 and Fig. 7 in MS). Therefore, we believe that it is acceptable to use these overlapped samples as research samples in this study. Although we have verified these research samples' representativeness of the whole country, we still need to briefly claim that being representative is not our research objective; instead, we need these samples to compare different approaches.

To address the first half of this comment, we will add related clarifications in the Method section in the revised MS: "First, we limited the analysis to only those pixels shared by all three approaches, and this resulted in 96058 sample pixels at 1km resolution. These spatially overlapping samples maintained the distributional characteristics of the original samples with similar outcomes (Fig. R1). Then, the average values of three approaches were calculated and compared."

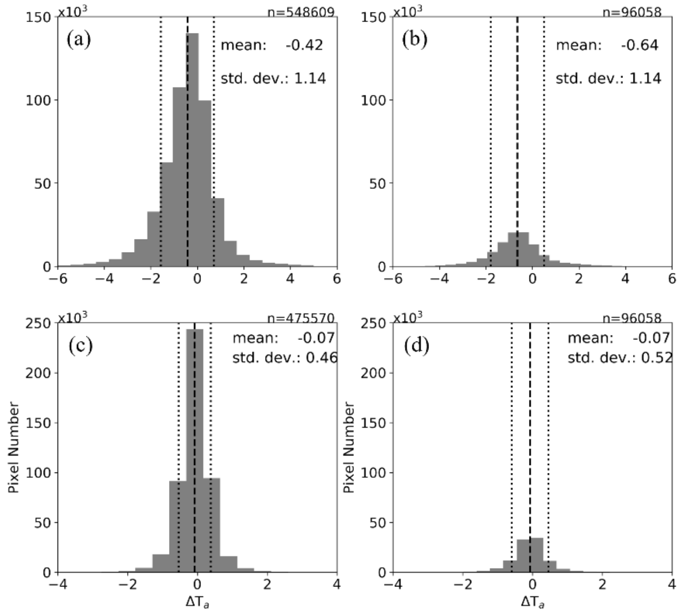

Figure R1. (a) Histogram of ΔT_a of all pixels based on GFC dataset (b) Histogram of ΔT_a for research samples. (c) Histogram of ΔT_{p1} of all pixels based on GFC dataset (d) Histogram of ΔT_{p2} for research samples.

3. L275-277, afforestation from GFC is not consistent with the inventory data, so can the results based on GFC be considered as the real biophysical effects of afforestation in China? I think this key message is important for policy makers.

The central objective of our study is to demonstrate the fraction of afforestation is a core factor that can reconcile different approaches. Thus, this question is a little out of our scope, but we addressed it in greater detail below.

We believe this question is related to the accuracy of afforestation from Global Forest Change (GFC). According to Hansen et al. (2013), considerable forest growth in China was not easily detected in time-series of satellite imagery (i.e., GFC) when compared to forest inventory assessed in FAO Forest Resource Assessment (FRA). This discrepancy may arise from the definition of 'forest', classification system, spatial resolution, and algorithm (Chen et al., 2020). Nevertheless, the GFC product shows an overall accuracy greater than 99% at the global scale for the observed forest gained area when it was compared with forest area statistics reported in FRA, LiDAR detection (Geoscience Laser Altimetry System), and MODIS NDVI time series. Therefore, GFC was recommended to be utilized in forest and forest change estimates (Chen et al., 2020).

In this study, the net forest gain area is about 24,372 km^2 based on GFC, while the overlapped region included in this research is about 1,400 km^2 (Fig. R2), both of which are significantly lower than 157,000 km^2 as indicated by National Forest Resources Inventory (SFA, 2014). We thus cannot give a precise evaluation of the actual biophysical effects of afforestation in China. Nevertheless, based on the analysis (Fig. R1), the distribution of research samples was similar to the original distribution on each afforestation intensity bin and maintained the same overall actual effect of -0.07 K.

To address this comment, we will provide a description of GFC's accuracy in the Method section and briefly claim that "this study cannot provide a precise actual effect of afforestation in China" in the Discussion section of the revised MS.

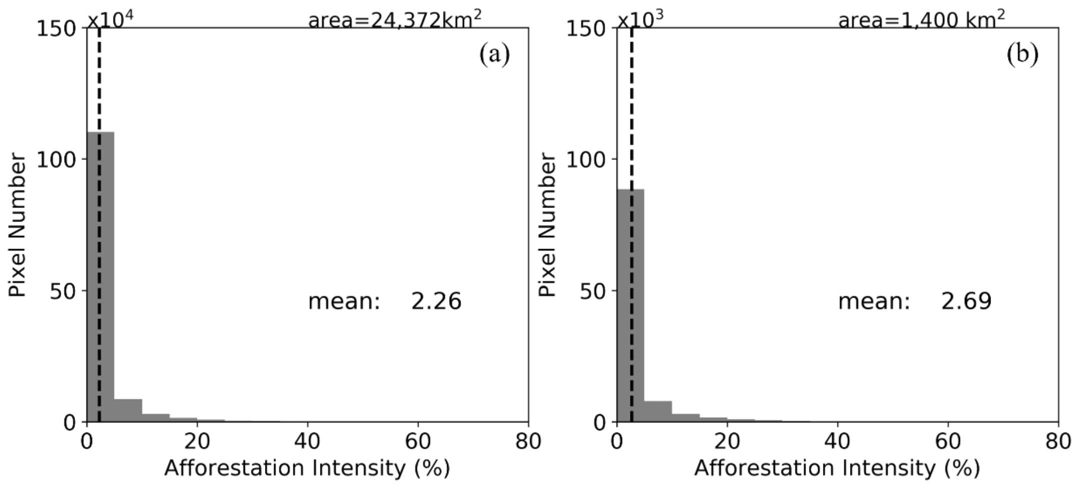

Figure R2. (a) Histogram of the afforestation intensity (%) based on net forest gain from GFC dataset (b) Histogram of afforestation intensity (%) from research samples.

4. L391, that's what I meant, the afforestation area is much smaller than the national inventory.

The specific reasons can be found in our responses to comment #3. Although this question is out of our research scope, we still clarified these two points on this question: Firstly, GFC was appropriate for use in detecting afforestation (Chen et al., 2020). Secondly, despite the result based on GFC cannot provide an accurate assessment of the actual biophysical effects of afforestation in China, this does not impede our understanding of the actual effects of afforestation (Fig. R1a, b). We will briefly discuss these in the Discussion section of the revised MS.

5. Fig. 4, better to show the latitudes on the left axis of (a)

We will add legends to Fig. 6.

6. Fig. 5, did you consider the spatial distribution of each bin? Whether the regions with higher F_{aff} happen to be in the tropics with larger cooling effects?

To address the reviewer's comment, we checked the ΔT_a within each afforestation bin in different climate zones (Fig. R3). On average, afforestation in the tropical zone had the strongest cooling effect, followed by the subtropics zone, temperate zone, and Qinghai-Tibet Plateau. Such climate zone patterns on the effect induced by afforestation have been reported by previous studies that forest restoration contributes to the surface cooling in tropical zones whilst minor warming might occur in boreal forest zones (Alkama and Cescatti, 2016; Li et al., 2015; Peng et al., 2014). More specifically, the cooling effect was stronger in the tropical zone than in other zones with the same afforestation intensity, which is consistent with our expectation since the enhanced evapotranspiration in the tropical would release more latent heat when afforestation with fixed intensity occurred than other regions with the same intensity (Li et al., 2016).

We will add discussion on "cooling effect in different climate zones with the same afforestation intensity" in the Discussion section and add Figure R3 in Supplemental Material.

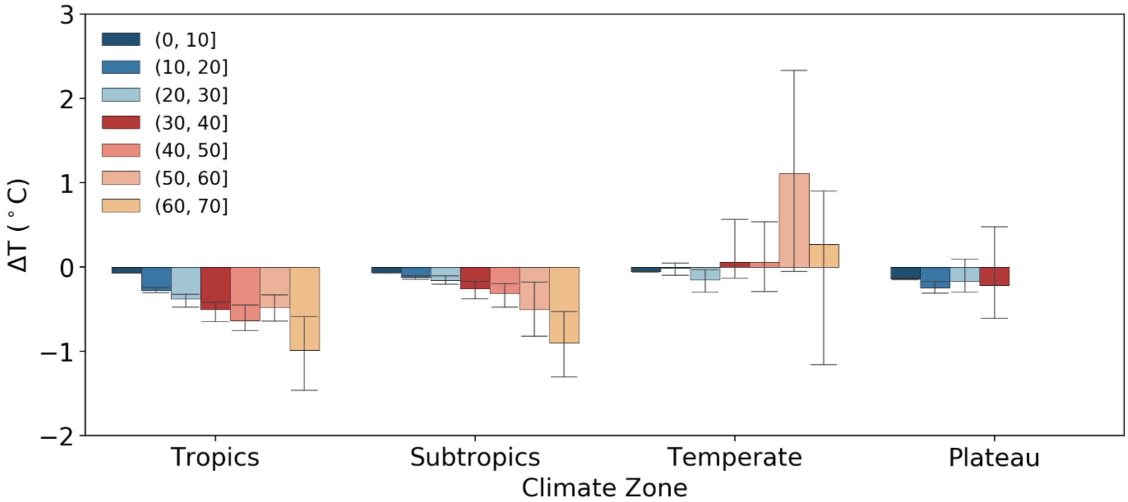

Figure R3. ΔT_a within each afforestation intensity (F_{aff}) bin over four climate zones (Tropics, Subtropics, Temperate and Qinghai-Tibet Plateau Plateau) in China. The climate zone was based on Climate Regionalization of China (https://www.resdc.cn/data.aspx?DATAID=243).

7. Fig. 8, I guess the differences for changes in seasonal fluxes would be much larger between the partial and full coverage of each pixel, especially in the snowing regions in winter.

We agree. Previous research has documented that in high-latitude regions the snow-covered short vegetation has larger albedo than forest in spring and winter, leading to a greater warming effect in the transition from openland to forest (Peng et al., 2014; Li et al., 2015; Lawrence et al., 2022). In our study, it is expected that the difference in seasonal fluxes between mixed potential (i.e., effects of partial coverage of pixels) and full potential effect was much greater, given that full transition can significantly amplify the albedo-induced warming effect at high latitude. Here, in the specific instance of shortwave radiation (SW_{out}), we added some seasonal flux analysis for the summer (June to August) and winter (December to February) seasons, respectively (Fig. R4 and R5). Fig. R5 shows that the magnitude of the full potential SW_{out} effect was stronger than the mixed potential effect (Fig. R4). In winter, there was a strong decrease in SW_{out} than in summer, and the decrease was larger for the boreal forest areas northward 45°N than the lower latitudinal areas southward 45°N due to the snow cover in the forest understory (Fig. R5).

We believe this part will supplement our results; therefore, this point will be briefly discussed in the Discussion section of the revised manuscript and Fig. R5 will be added in the Supplemental Material.

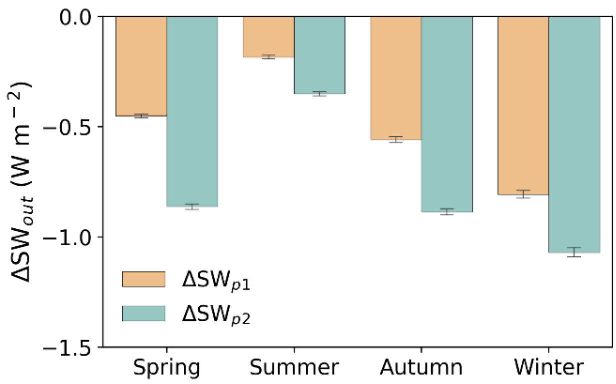

Figure R4. Afforestation-induced changes in seasonal reflected shortwave radiation (SW_{out}) based on mixed potential and full potential effect.

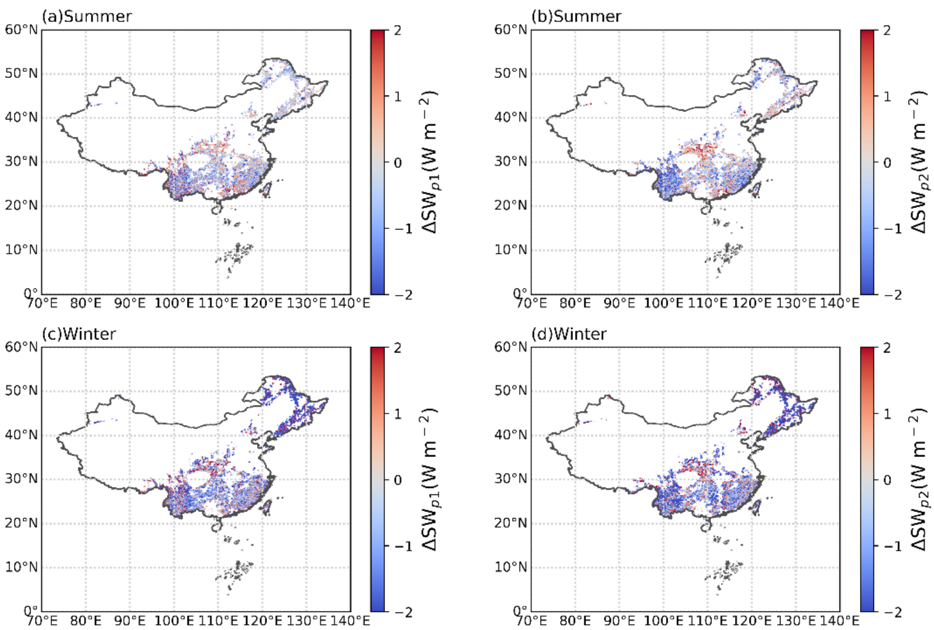

Figure R5. Spatial patterns of changes in seasonal reflected shortwave radiation (SW_{out}) during (a) (b) summer and (c) (d) winter for mixed potential and full potential effect.

8. L742, should be Nature Communications

We will modify it as Nature Communications.

References used in the responses:

Alkama, R. and Cescatti, A.: Biophysical climate impacts of recent changes in global forest cover, Science, 351, 600–604, https://doi.org/10.1126/science.aac8083, 2016.

Chen, H., Zeng, Z., Wu, J., Peng, L., Lakshmi, V., Yang, H., and Liu, J.: Large Uncertainty on Forest Area Change in the Early 21st Century among Widely Used Global Land Cover Datasets, Remote Sensing, 12, 3502, https://doi.org/10.3390/rs12213502, 2020.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., and Loveland, T. R.: High-resolution global maps of 21st-century forest cover change, science, 342, 850–853, 2013.

Lawrence, D., Coe, M., Walker, W., Verchot, L., and Vandecar, K.: The Unseen Effects of Deforestation: Biophysical Effects on Climate, Front. For. Glob. Change, 5, 756115, https://doi.org/10.3389/ffgc.2022.756115, 2022.

Li, Y., Zhao, M., Motesharrei, S., Mu, Q., Kalnay, E., and Li, S.: Local cooling and warming effects of forests based on satellite observations, Nature Communications, 6, 6603, https://doi.org/10.1038/ncomms7603, 2015.

Peng, S.-S., Piao, S., Zeng, Z., Ciais, P., Zhou, L., Li, L. Z. X., Myneni, R. B., Yin, Y., and Zeng, H.: Afforestation in China cools local land surface temperature, Proceedings of the National Academy of Sciences, 111, 2915–2919, https://doi.org/10.1073/pnas.1315126111, 2014.

SFA (2014) Report of forest resources in China (2009-2013). China Forestry Press, Beijing, p 86