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Comment on bg-2021-261

Anonymous Referee #1

Referee comment on "Strong influence of trees outside forest in regulating microclimate of intensively modified Afromontane landscapes" by Iris Johanna Aalto et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-261-RC1>, 2021

Biogeosciences

MS No.: bg-2021-261

Title: Strong influence of trees outside forest in regulating microclimate of intensively modified Afromontane landscapes

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MS type: Research article

Iteration: Initial submission

General comments:

This paper aims to examine the effect of canopy cover on microclimate in an intensively modified Afromontane landscape in Taita Taveta, Kenya. The authors studied microclimate sensors under different canopy covers, and land surface temperature (LST) from Landsat 8 thermal infrared sensors and combined these data with high-resolution airborne laser scanning data to disentangle combined effects of topography and canopy cover on microclimate. This is an interesting comparison of temperatures across canopy cover changes, forest types, and elevational gradients to help understand thermal regulation by forests and microclimates that buffer species and local climate against warming.

A strength of the study is that it utilizes multiple temperature datasets (in situ and remote sensing) and that it includes study sites along an elevational gradient with CC changes. The study shows a strong negative relationship between canopy cover and temperature, with the strongest effect on maximum temperature. Results are well reported with good figures. The main weakness of the paper is that it does not carefully describe the different physical measurements, what they actually measure, and how they related and interact. The link between microclimate and LST is not clearly established.

Main comments

Introduction

- The flow and clarity of the manuscript could be improved. The second paragraph of the Introduction attempts to cover a large range of topics, spatial scales, and physical measurements and is confusing as written. It could be improved with better explanations and breaking in into two separate paragraphs. One paragraph could focus on forests, TOF, the goods and services they provide, and the land use factors impacting these systems. The second paragraph could focus on microclimates and improved description of other temperature measurements and how they relate.

Line 40-41 describes the values of Forests and TOF as “vital ecosystem services” which I think implies that they are source of many goods and services to humans (ie. That next sentence is redundant). When you say that forests and TOF are “also a source of goods for humans,” are you actually referring to uses that degrade forests, such as logs for building or firewood gathering? This should be clarified because it can conflict with the ecosystem services you have just described. The tension between what forests provide when they are left standing, and how they are used for raw materials sets the stage for the existing condition of your study area.

On lines 97 to 102 of the Methods you describe this. But I think this is important background on TOF and helps readers understand why TOF are important (e.g. carbon storage and biodiversity). I recommend moving these lines to the Introduction to complete the TOF paragraph.

- Line 44-53: I recommend a new paragraph starting with the definition of microclimate. The description of microclimates is provided at a scale of centimeters to meters (line 45) which does not always seem congruent with your application of the term microclimate, and the spatial focus of the study. It seems that you are interested in microclimatic buffering capacity of forests at much larger scales? This may in part be a problem with definitions as microclimates can also be defined at very localized scales to describe unique thermal niches within context of the overall forest thermal environment. This seems different than the climatic conditions below forest canopies in

general sometimes referred to as “microclimatic buffering”. I recommend defining microclimate so that it incorporates the spatial domain of your study question.

For example, the De Frenne study states “...the local temperature experienced by living organisms (referred to as the ‘microclimate’)... While quite general, this definition includes the thermal regulation of forests across scales.

Lines 48-45: The authors compare understory microclimate variability to continental scale studies of spatial variability in LST measurements. LST is canopy temperature, a different physical measurement that indicates partitioning of solar radiation driven by transpirational cooling. I think you should add a sentence recognizing the differences in these physical measurements and that you are inferring a relationship between radiometric surface temperature and understory temperatures especially since the relationship between these various temperature measurements are not well understood.

- Line 56: Numerous studies have examined forests and moisture gradients using LST and thermal imagery from fine to moderate scales.

Scherrer, D. M. K-F. Bader, and C. Korner. 2011. Drought-sensitivity ranking of deciduous tree species based on thermal imaging of forest canopies. *Agricultural and Forest Meteorology*, 151, 1632-1640.

Kim, Y., Still, C.J., Hanson, C.V., Kwon, H., Greer, B.T. & Law, B.E. (2016). Canopy skin temperature variations in relation to climate, soil temperature, and carbon flux at a ponderosa pine forest in central Oregon, *Agricultural and Forest Meteorology*, 226, 161-173.

Mildrexler, D.J., Yang, J.Z., & Cohen, W.B. 2016. A Forest Vulnerability Index Based On Drought and High Temperatures. *Remote Sensing of Environment*, 173, 314-325.

- Line 56-60: Consider that lines 103-107 of the Methods would make more sense added

here. You are describing the climate mitigation potential of forests and TOF, so this would be a good place to highlight the projections for your study area that make this so important.

- 62-72: The background on LST and CC should also note the well-described negative relationship between LST and vegetation density. It is key to your study of fractional vegetation coverage (see references below for examples). This addition would be a good transition into the paragraph starting at line 68 that describes some of the commonly used vegetation indices used to study this relationship.

Nemani, R. R., and S. W. Running 1997. Land cover characterization using multitemporal red, near-IR, and thermal-IR data from NOAA/AVHRR, *Ecol. Appl.*, 7, 79–90.

Goward, S. N., Cruickshanks, G. D., & Hope, A. S. (1985). Observed relation between thermal emission and reflected spectral radiance of a complex vegetated landscape, *Remote Sensing of Environment*, 18, 137-146.

Goward, S. N., & Hope, A. S. (1989). Evapotranspiration from combined reflected solar and emitted terrestrial radiation: Preliminary FIFE results from AVHRR data., *Advanced Space Research*, 9, 239-249.

Methods and Results

- Microclimatological field measurements: Is it common in microclimatological field measurements for Tair to be only 15 cm from the ground? It seems that measurements so close to the ground would be influenced by the surface temps. I am accustomed to Tair from weather stations where it refers to temperatures measured 1.5 meters above the ground surface as in:

Oyler, J. W., S. Z. Dobrowski, Z. A. Holden, and S. W. Running, 2016: Remotely sensed land skin temperature as a spatial predictor of air temperature across the conterminous United States. *J. Appl. Meteor. Climatol.*, 55, 1441–1457

- Lines 150-175. The authors use a single channel method to derive LST as a work around to the stray light problem with TIRS band 11 on board Landsat 8. Can you report the uncertainties associated with this approach?
- Figure 5: This is for mean temperatures. Why not show a similar scatterplot sequence for maximum temperatures?

Discussion

- The Discussion contains more grammatical problems compared to the rest of the manuscript. I encourage the authors to edit this section for grammatical consistency with the rest of the manuscript.
- Lines 320-322: States that results revealed trees on farms had the same effect on local temperatures as forests... Please refer to the figure or data specifically from the results that supports this finding.
- Lines 323-325: Can you say on average how much cooler these moderately forested TOF sites in agriculture are vs. ag with no TOF?
- Lines 327-328: This is a great link to local policy. Please state how much the difference in temperature 10% forest cover makes here.
- Lines 334-336: The link between forest and water for agriculture is important. You highlight fog drip here, but what about forests supporting clean water to farms, water retention through increased soil organic matter, and hydraulic redistribution? In other words, try to strengthen this section.
- Lines 337-338: It is not obvious to me why increasing the tree cover on farms would mitigate pressure on tropical forests from fuelwood collection. I presume that farms are private land, and fuel wood collection is not permitted by the general community, but I do not know. Please explain this.
- Lines 349-351: topographic manipulation of the temperatures? Do you mean "accounting for the effect of topography on LST measurements..."?
- 354-355: Can you report an uncertainty estimate for the LST product?
- 355-356: Here you state that LST may not be representative of understory conditions. Wasn't this part of your study? What did you find?
- 360: I recommend adding the following citation to this sentence:

Davis, K. T., Dobrowski, S. Z., Holden, Z. A., Higuera, P. E., and Abatzoglou, J. T. (2019a). Microclimatic buffering in forests of the future: the role of local water balance. *Ecography* 42, 1–11. doi: 10.1111/ecog.03836

369-370: At line 356 you questioned whether LST is representative of understory conditions and provided citations. Here you state that your results showed that LST can be used as a proxy for assessing the impacts of CC on microclimate. Do your results really show this? Or do they show that an increase in canopy cover results in a commensurate decrease in LST?

Other Specific Comments:

Line 140: delete "laying" so sentence reads "as the plot was outside of the ALS coverage."

Line 191: Reword to: CC also affected temperature variability

Line 287: In addition to sensible heat flux, could some of the cooling effect be due to transpirational cooling?

298: Change discovery to finding.

292: prevalent doesn't make sense here. Please clarify.

295: "One likely reason...": isn't another likely reason that on cloudy days there is less solar insolation at the surface, which has a disproportionately large effect on warming areas with low CC on sunny days?

314: Change extent to magnitude

328: Can simplify sentence to "Soil and air temperatures impact crop productivity,..."