

Biogeosciences Discuss., author comment AC2
<https://doi.org/10.5194/bg-2021-95-AC2>, 2021
© Author(s) 2021. This work is distributed under
the Creative Commons Attribution 4.0 License.

Reply on RC2

Trina Merrick et al.

Author comment on "Unveiling spatial and temporal heterogeneity of a tropical forest canopy using high-resolution NIRv, FCVI, and NIRvrad from UAS observations" by Trina Merrick et al., *Biogeosciences Discuss.*, <https://doi.org/10.5194/bg-2021-95-AC2>, 2021

Dear Reviewers,

Thank you for giving us the opportunity to submit a revised draft of the manuscript "Unveiling spatial and temporal heterogeneity of a tropical forest canopy using high-resolution NIRv, FCVI, and NIRvrad from UAS observations" for publication in *Biogeosciences*. We appreciate the time and effort required to provide feedback on our manuscript and are grateful for the insightful comments that have led to valuable improvements to our paper. We have incorporated most of the suggestions made and highlighted those within the manuscript. Please see below, in for a point-by-point response to the reviewers' comments and concerns with line numbers noted.

RC2: 'Comment on bg-2021-95', Anonymous Referee #2, 13 May 2021

▪ General Comments

- The authors present a very interesting and novel dataset of high-resolution vegetation indices (VI) in a tropical forest. They present correlations of the VIs to the gross primary productivity (GPP) of this forest and show how the VIs compare in capturing GPP for a given day. The authors also present a comparison of the VIs in their ability to capture structural heterogeneity of the forest. I found the study to be relevant and current given the emerging VIs used in this study. The spatial component of this study is very interesting as well. Here the authors show that NIRv and FCVI can capture more spatial heterogeneity in this forest in the reflection and absorption of radiation. My comments mostly focus on encouraging enhancement of the discussion that could provide more context for the analysis that was done and reducing the discussion of distracting concepts that were not tested. To tie the introduction and discussion to the analysis and results, the discussion and the introduction could better explain why NIRv_rad would be correlated to GPP with a clearer explanation of the GPP and NIRv (reflectance or radiance based) relationship and a reduced discussion of the role of the VIs in the SIF-GPP relationship. The paper could benefit from discussing the connections between canopy structure (height, size of tree clusters) and function (GPP) rather than the links between VIs and SIF. Below are some specific comments.

▪ Specific comments

- The Light-Use Efficiency (LUE) model is the most widely used model to explain the relationship between GPP and vegetation indices such as NDVI as mentioned by the authors in line 42. I find the description of the LUE model to be inadequate in this

paper considering it plays such a key role in understanding why vegetation indices correlate with GPP. Thinking of NIR_v as an indicator of fPAR x f_{esc} could serve an analysis which includes observed SIF, but for the current analysis, it would be better to discuss NIR_v_rad as an indicator for APAR. I would encourage the authors to present either: the equation for the LUE model with an explanation of the terms or a written description of the LUE logic and a description of its terms. Medlyn (1998) and Yuan et al. (2014) provide overviews of the LUE model and its terms. Presenting the LUE model can help readers understand exactly where vegetation indices fit in estimating GPP when one does not have SIF observations and would help clarify vague sentences like "thus a joint relationship between a remote sensing vegetation quantity, PAR, and GPP." (lines 206 – 207)

- This insight is particularly helpful to clarify our message for the readers. We have updated the manuscript to remove the emphasis on fPAR x f_{esc} and to include information about the links to LUE (Lines 58-62). Additionally, based on this comment, others by this reviewer, and those made by other reviewers, we have significantly cut the introductory material related to the SIF~GPP~vegetation indicator descriptions and links because we did not measure SIF. We feel as if this provided a clearer background for our study focusing on traditional RS vegetation indicators and emerging indicators.
- Since the study focuses solely on vegetation indices, can the authors expand more on why near-infrared reflectance or reflected near-infrared radiation and the vegetation indices that are built from it have shown good correlations with GPP?
 - We fine-tuned the introduction to the vegetation indicators and GPP to provide links, especially based on previous studies in Lines 62-70. We follow this portion of the manuscript with a careful description of the traditional and emerging vegetation indicators without pulling in tertiary information not related to what we are testing, such as SIF. We feel this now provides a better basis for our study.
- Making a clearer link between spatial canopy heterogeneity and GPP in the discussion can also help tie both the correlation and the power spectrum analysis together.
 - Thank you for this suggestion. We have updated the introduction, results and discussion to include better links between canopy spatial heterogeneity and GPP Lines 38-44, 49-55, 228-234, 289-297.
- I find the discussion of SIF here to be a bit too extensive given that SIF was not actually tested. The authors have covered an important point in mentioning the use of NIR_v to capture the structural component of observed SIF and it is worth mentioning in a sentence or two, but I think an analysis which is not focused on a comparison between SIF and VIs does not need to explain how VIs are related to SIF as extensively as has been done. Instead, a focus on how near-infrared reflectance of vegetation, canopy structure, and light capture/absorption is related to GPP could help address the actual comparison being made. If the authors want to focus on how NIR_v can be used in the GPP-SIF relationship, then the links between NIR_v, SIF, and GPP need to be discussed further to allow a reader to understand what role NIR_v plays in estimating GPP through the GPP-SIF relationship. Expanding the fPAR x f_{esc} equation to show the full GPP equation could help in this area. However, again, since the NIR_v-GPP relationship was tested, the LUE model without SIF is a better conceptual glue for this analysis.
 - Thank you for these helpful and very detailed suggestions. Based on this reviewer's perspective, we updated the manuscript, especially the introduction, to increase the focus on NIR_v, FCVI, and NIR_vrad and reduce the focus on SIF.

Specifically, we removed paragraph 2 from the introduction, as well as extraneous references to SIF in Paragraph 3 (Lines 52-101). We only retained a reference to SIF in regard to comparing techniques for measurement (Lines 78-81), measurements of FCVI in our study related to SIF (Lines 88-90), studies specifically comparing the vegetation indices to GPP and SIF (Line 96), and in the discussion regarding uses for emerging vegetation indices (Lines 295-296 and 316-319).

- Line 113: Can the authors expand on why NIRv needs to serve as a proxy for SIF if it can serve as a proxy for GPP and a radiance based NIRv can serve as a proxy for APAR? Using NIRv for addressing the structural component of the SIF-GPP relationship makes sense, but the utility of using NIRv as a proxy for SIF is not as clear.
 - We agree that stressing the connection between NIRv, NIRvrad, and SIF takes away from the central message that these metrics from UAS provide fine-scale structural information that may help address gaps in understanding GPP. Based on this helpful suggestion, we have scaled back references to SIF, and specifically removed the references in Line 113.
- R in equation 3 and equation 4 is not explained until after equation 5. It can be clearer to explain what R represents after equation 3 and 4.
 - Apologies for this oversight. We have now corrected this omission (Lines 158-161).
- It is unclear how this analysis supports the claim at line 236 since normalizing SIF with the UAS data was not done in this study.
 - Thank you, we have removed this reference to normalizing SIF as a part of focusing the manuscript more clearly on NIRv, FCVI, and NIRvrad (Lines 230).
- Claims made at the following lines need citations: line 32 – 33, lines 56 – 57, lines 75 – 76, lines 78 – 80, lines 91 – 94
 - We added appropriate citations for lines 32-33 (now Lines 41-42). Due to modifications related to decreasing the discussions of SIF in the introduction, Lines 52-101 were removed from the manuscript. Thank you for pointing out these omissions.
- **Technical Corrections**
 - Line 49 – 50: consider changing “and questions linger about their ability to track green-up with RIs in tropical regions” to “and questions linger about the ability to track green-up with RIs in tropical regions” or “and questions linger about their ability to track green-up in tropical regions”
 - Thank you for this helpful suggestion, we have reworded according to your advice (lines 49-53).
 - Line 84: consider changing “SIF signal or used to independently as” to “SIF signal or used independently as”.
 - This is a helpful suggestion, but this sentence has been removed in this revision.

References

Medlyn, B. E.: Physiological basis of the light use efficiency model, *Tree Physiology*, 18,

167–176, <https://doi.org/10.1093/treephys/18.3.167>, 1998.

Yuan, W., Cai, W., Xia, J., Chen, J., Liu, S., Dong, W., Merbold, L., Law, B., Arain, A., Beringer, J., Bernhofer, C., Black, A., Blanken, P. D., Cescatti, A., Chen, Y., Francois, L., Gianelle, D., Janssens, I. A., Jung, M., Kato, T., Kiely, G., Liu, D., Marcolla, B., Montagnani, L., Raschi, A., Rouspard, O., Varlagin, A., and Wohlfahrt, G.: Global comparison of light use efficiency models for simulating terrestrial vegetation gross primary production based on the LaThuile database, *Agricultural and Forest Meteorology*, 192–193, 108–120, <https://doi.org/10.1016/j.agrformet.2014.03.007>, 2014.

Thank you for bringing these references to our attention. We have corrected this omission and included the information and appropriate references (Lines 59, 61, 68, 556-557, 671-676).