Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-360-AC2, 2021

Biogeosciences
Discussions

Interactive comment on "Retrieval and validation of forest background reflectivity from daily MODIS bidirectional reflectance distribution function (BRDF) data across European forests" *by* Jan Pisek et al.

Jan Pisek et al.

janpisek@gmail.com

Received and published: 8 January 2021

We thank the reviewer Alexei Lyapustin for his comments and suggestions that would help to improve our original submission. The instructions for our final response state that revised manuscript should not be prepared/provided at this stage. For clarity, in our replies we provide the revised versions of the individual sentences following the reviewer's suggestions.

The paper by Pisek et al evaluates possibility of assessing the understory NDVI using

site-level ground characterization and MODIS BRDF data (MCD43). Overall, it's a large work, the results are reasonable and deserve publication. My main comments are following (details are provided in the file attached): 1) Please explain the method in more detail. For instance, I've got an impression that the reflectances of understory and trees in the retrieval model are assumed Lambertian. If that's true then it should be explained, as well as the limitations of such assumption.

REPLY: We do not claim the vegetation targets (overstory, understory) are Lambertian reflectors (reflecting electromagnetic radiation equally in ALL DIRECTIONS), because they are not. At the same time, the retrieval approach relies on an assumption that at the given illumination geometry, there can exist viewing directions where reflectance factors would differ little between selected viewing angles. Several previous studies (e.g. Bacour & Bréon, 2005; Deering et al., 1999; Peltoniemi et al., 2005) found forward-scattering reflectance factors of various targets off the principal plane to be fairly constant. The most suitable viewing configuration for the understory signal retrieval (and the one used in this study as well) has been identified by Pisek et al. (2015, RSE) using a high angular resolution BRF dataset of Kuusk et al. (2014) and accompanying in situ measurements of understory reflectance factors (Kuusk et al., 2013). Please note that in that respect there is nothing new about the applied methodology and the assumptions that come along with it. We made sure we include all the important references related to the methodology and assumptions (e.g. Canisius and Chen, 2007, RSE; Pisek et al., 2015, RSE). Following the reviewer's request, we will include additional text and references in the revised version.

2) Presently, you are just saying that the method works well for open canopies. Since certain statistics is accumulated, please provide an assessment of the accuracy for derived NDVI of understory. More importantly, provide the same the for the Red and NIR and reflectances which is much more valuable as the NDVI is a non-linear function.

REPLY: We understand the reviewer's point. Accuracy of our approach would depend on the information about the forest stands that serves as an input to retrieve the propor-

tions of individual components (sunlit/shaded trees/understory). The better we know these parameters, the more likely we can provide accurate retrievals. Since the information such as tree density, height or tree crown parameters is not always known, we followed Gemmell's (2000, RSE) logic and opted to report a range/window of understory NDVI (NDVIu) values obtained with the combinations of parameter values from Table 2 for each site and date. Specifying the correct constraints (window) for background alone has been previously found to greatly reduce the errors in the estimation of overstory parameters (Gemmell, 2000, RSE). In that sense we consider our product sufficiently accurate at this stage if the in situ measured values are located within the range (blue, orange bars in our Figures 4 and 5) of values predicted using the MODIS BRDF data. In our Results/Discussion we focused on highlighting and explaining the cases when the in situ measured values were found outside these ranges, and we were able to track and identify sources of the disagreement (e.g. closed canopies, site non-representativeness, MODIS data marked with lower quality flags, etc.). We were trying to deliver what Gemmell (2000, RSE) had asked for – the constraints/window for background values alone. Please note that in our manuscript we focused and were able to explain the cases when the in situ measured values were found OUTSIDE the window of values obtained with the MODIS BRDF product. Yes, we can do what the reviewer is asking for and assess the accuracy using e.g. the mean of predicted understory NDVI values and compare it with in situ values. We were just not sure if such assessment would provide a true picture in this case. Also, please note that once we omit the closed canopy (FC > 0.85) or spatially non-representative sites, we end up with only around 20 sites. Filtering the sites by quality flags of MODIS BRDF product would reduce the number of sites even more. We were not convinced such a small pool offers a representative sample for such assessment. Also please note that at the same time (at least to our knowledge), this study offers the largest pool of sites with in situ measured reflectances reported in the literature so far. We would like to comply with the reviewer's wishes but we also want to make sure we do not provide any potentially misleading information just for sake of calculating/providing numbers, and that's

why we did not include them in our submission. Our limited assessment may still meet Validation Stage 1 as defined by the CEOS LPV subgroup.

Also, for paper to be of any value, please provide an assessment of threshold for the canopy fraction below which the method you think should work to the specified accuracy.

REPLY: Accepted. We provide the following statement with foliage cover value explicitly stated: 'The method can deliver reasonable retrievals over different forest types with canopies where foliage cover does not exceed 85 %.'

Alexei. Please also note the supplement to this comment: https://bg.copernicus.org/preprints/bg-2020-360/bg-2020-360-RC2-supplement.pdf

REPLY: the comments from the supplement are inserted and answered below.

L91 - Please, refer to Tucker

Reply: Accepted. We add reference to Tucker (1979).

L155 - the sentence is not finished.

REPLY: Accepted. Here is the full sentence with the missing part added: When a tuning parameter (called "structuring element" in image processing) was set so that "large" gaps only occurred between individual tree crowns (Korhonen and Heikkinen, 2009), the proportions of gaps inside and between individual crowns could be calculated.

L161 - Your subscripts are not intuitive - please explain them. I figured that T is for trees, and G is for ground. What Z stands for?

REPLY: Accepted. We re-arrange the sentence to make it clearer: which includes reflectivities of the sunlit crowns (R_T), sunlit understory (R_G), shaded crowns (R_ZT,), and shaded understory (R_ZG).

L175 - Are you assuming that Rt, Rg, Rzt and Rzg do not depend on view angles?

REPLY: In this retrieval approach we work with the assumption that there exists a viewing configurations where the reflectance factors vary little between SELECTED angles (not all angles, but the selected ones). We stated this on L472-474 in our original submission.

L210 - The kernels are Ross and Li - please refer to those.

REPLY: Accepted. We refer to the kernels as Ross and Li in the revised text.

L210 - What you mean is you computed the BRF at the top of canopy using MCD43A1. And then derived the understory reflectance using the formulas described above. Please say so.

REPLY: Accepted. The revised statement is as follows: We computed the bidirectional reflectance factor (BRF) at the top of canopy with the isotropic parameter and two (volumetric and geometric) kernel functions (Roujean et al., 1992) for MODIS band 1 (red, 620–670 nm) and band 2 (NIR, 841–876 nm). We used the Ross and Li kernels to reconstruct the bidirectional reflectance factor (BRF) values for required geometries (see section 2.3) for each date, and then derived the understory signal using the formulas described in Section 2.3.

L276 - What is LUTs? Table 2 has no LUTs.

REPLY: Accepted. The reviewer is right. The statement has been revised: 'Extremely low tree density does not match with any original generalized input parameter values in Table 2 and the predicted understory signal does not match well with in situ measurements.'

L280 - To what accuracy? I would prefer to see the separate accuracy assessment for Red and NIR bands. Reply: To assess the decrease in accuracy quantitatively, we would have needed the high quality (QA=0) MODIS inputs for the same day - when the in situ retrievals were collected. But these are not available.

L285 - "shadowing" cannot be a "scattering mechanism".

REPLY: Accepted. We revise the sentence: 'This is because shadowing effect makes diffuse scattering the dominant mechanism in such stands, and understory carries only a negligible influence on the top-of-canopy signal'.

L365 - Terrible explanation. You only explain green color - this is NDVI from NBAR. What is blue and orange? Is it NDVI computed from MODIS BRDF or something else? If yes, why Green line is not in the middle of, say orange, for Yeste?

REPLY: Accepted. We modifiy the figure caption following the suggestions by the Reviewer 1: Figure 6. Seasonal courses of estimated understory NDVI (NDVIu) ranges (blue bars for site representative retrievals; orange bars for possible site non-representative retrievals), nadir total (understory+overstory) NDVI values from MODIS BRDF/albedo data (green lines), in situ measurements (mean +/- 1 standard deviation shown in purple) over select study sites. Gray bars mark MODIS BRDF parameters with lower quality flags (light gray, QA=1; dark gray, QA>1); black bars - no data available.

The green line is not in the middle of the NDVIu range (in orange) for Yeste, because it marks the total NDVI signal (including overstory as well).

L403 - Please, provide CF where you think the method works reasonably well. Also, please specify to what accuracy (for NDVI, and Red and NIR reflectance).

REPLY: Accepted. We provide the following statement with foliage cover value explicitly stated: 'The method can deliver reasonable retrievals over different forest types with canopies where foliage cover does not exceed 85 %.'

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-360, 2020.