Answer to reviewer comments

Manuscript: AnisoVeg: Anisotropy and Nadir-normalized MODIS MAIAC datasets for satellite vegetation studies in South America

Authors: Ricardo Dalagnol, Lênio Soares Galvão, Fabien Hubert Wagner, Yhasmin Mendes Moura, Nathan Gonçalves, Yujie Wang, Alexei Lyapustin, Yan Yang, Sassan Saatchi, and Luiz Eduardo Oliveira Cruz Aragão

Reviewer comments are colored black, our answers are colored blue

Reviewer #4 – RC4

This manuscript presents the NAD (nadir-normalized) and ANI (backward-forward) surface reflectance and VI dataset produced from MAIAC MCD19A1 daily surface reflectance and 8-day MCD19A3 product. It provides possible chances to reduce uncertainty or extract information to serve the vegetation studies. Before the publish of this manuscript, further efforts may be needed to address the following general and special comments.

General comments:

1. Several anisotropy indices except ANIX have been published in the anisotropy community. There is a need to summarize out these typical indices with advantage and disadvantage, to establish the requirement of the presented metrics NAD and ANI.

Addressed in revision: Indeed, we could have explored more about this subject. We had included a brief explanation that we provide the data to calculate other anisotropic indices, but we did not explain why we chose ANI. We adjusted a paragraph in the "4. Prospective use of the dataset" section, stating that:

"Furthermore, auxiliary backward and forward scattering data are also available with the dataset. Beyond the use of the provided ANI layers, this effectively allows the computation of several other multi-angular anisotropy indices from the literature (Table 3). The advantage or disadvantage of one specific anisotropy index rather than others is not established in the literature given the range of vegetation applications and the lack of available datasets up to date. We calculated and provided only ANI due to its demonstrated relationships with Amazonian forests structure and functioning (Moura et al., 2015; Moura et al., 2016; Hilker et al., 2017). However, we expect other indices, including ratios and normalized differences between the backward and forward scattering components, offer additional possibilities for tropical vegetation studies which should be explored in future studies."

2. Confused by the "backward scattering" and "forward scattering" of Table 2, without the description of given the sun-view geometry for the fixe kernel values. Either "backward scattering " or "forward scattering"is not an sole direction.

Addressed in revision: We understand the confusion. This was due to Table 2 appeared in the text before the text explanation to backward and forward scattering, which included the solar zenith angles, view zenith angles and relative azimuth angles. To clarify, we added this information to the Table 2:

Table 2 – View-angle normalizations and corresponding BRDF kernel values.

View-angle normalization	***Solar Zenith Angle (SZA, º)***	***View Zenith Angle (VZA, º)***	***Relative Azimuth Angle (RAA, º)***	F_{0V}	F_{0G}
Nadir	45	0	0	-0.04578	- 1.10003
Backward scattering	45	35	180	0.22930469	0.017440045
Forward scattering	45	35	0	-0.12029795	-1.6218740

3. Not sure why 35°is adopted. Is it an arbitrary determination? Through hotspot is around 45°, but probably varying within a limited direction, thus why not other VZA? Such as 40°?

Addressed in revision: The 35deg VZA was justified in the original submission and followed the recommendation of a previous study from the literature according to empirical observations of the MODIS observations. This is the sentence from the manuscript: "To minimize potential errors of BRDF extrapolation, the VZA was set to 35º instead of the hotspot (45º), because 35º is a very common VZA in the empirical data distribution of the South America, and thus providing better estimates of the anisotropy (Moura et al., 2015).".

To clarify this in the updated manuscript, we edited the sentence to make it clearer: "The VZA was set to near hotspot (VZA = 35º) instead of the actual hotspot (VZA = 45º) to keep VZA closer to the actual range of MODIS observations across the South America and minimize errors coming from extrapolation of the BRDF (Moura et al., 2015)."

4. Is it enough to grade the uncertainty of the produced data ONLY using the number of samples? How about the pixel-based quality of ingested input MCD19A1/A3?

Addressed in revision: This is a good point. A complete uncertainty assessment of the MAIAC BRDF estimates and on the variability in the anisotropy estimates have been thoroughly conducted in previous studies (Hilker et al., 2012; Moura et al., 2015) – cited in the main manuscript, so we do not intend to re-do all that work by any means. One thing it would have been possible was to retrieve the per-pixel BRDF uncertainty from the daily MCD19A1 observations for every band and then get the estimate related to the median observation amongst the set of 30-day observations, and finally combine between back and forward scattering. However, this process would have been a lot of extra computation to do and would not necessarily be used by the user of the dataset. We provide the number of samples which can easily be used as a simple indicator of how robust your median 30-day observation can be - this is explained in the manuscript.

5. It's hard to conclude there is a "significantly but weakly" association between EVI_NAD and forest height, when R^2=0.161. How about the effect of terrain?

Addressed in revision: Good point. EVI is known to be affected by topography, which would appear into the EVI_{NAD} estimates. Meanwhile, EVI_{ANI} may have removed part of this effect by considering the difference between the two view-angles, but at the same time higher EVI_{ANI} values were observed in over high slope areas in the Amazon (results not shown). This point was raised by Reviewer #1 and a paragraph was added in the previous review to address this concern regards the topography effect. To clarify this effect also for EVI_{NAD}, we edited the sentence to:

"Terrain illumination is a factor of spectral variability, which can affect EVI_{NAD} determination and its relationship with biophysical attributes of vegetation, as shown by previous literature (Huang et al., 2010; Chen and Cao, 2012). Even at 1-km spatial resolution, EVI_{ANI} results of Figures 3, 4 and 5 can be affected to some extent by terrain illumination effects observed locally at some sites. For instance, topographic effects on EVI_{ANI} occurred probably at the São Felix do Xingu site where topographic roughness, observed in SRTM data (results not shown), was coincident with increased EVI_{ANI} values in Figure 3E. Furthermore, even in relatively flat terrains, variations in topographic aspect (surface orientation to Sun) can affect the EVI variability in MODIS data because of the different amounts of energy reflected in the NIR towards the sensor by inclined surfaces in the forward and backscattering view directions. Such effects have been observed in southern Brazil with MODIS at 250-m spatial resolution and increased in magnitude at higher spatial resolution data obtained by other sensors (Galvão et al., 2016). Therefore, it may prove useful to include topographic variables in modelling exercises to offset these effects."

Wei, H., Zhang, L., Furumi, S., Muramatsu, K., Daigo, M., & Li, P. (2010). Topographic effects on estimating net primary productivity of green coniferous forest in complex terrain using Landsat data: A case study of Yoshino Mountain, Japan. *International Journal of Remote Sensing*, *31*(11), 2941–2957. https://doi.org/10.1080/01431160903140829

Chen, W., & Cao, C. (2012). Topographic correction-based retrieval of leaf area index in mountain areas. *Journal of Mountain Science*, *9*(2), 166–174. https://doi.org/10.1007/s11629-012-2248-2

Special comments:

6. Line 59-62: The description of anisotropy definition is not appropriate. Anisotropy is the intrinsic characteristics of objects, which can be captured by directional observations, but not determined by observations. Further, the surface reflectance varies not ONLY with VZA and SZA.

Addressed in revision: Agreed. This was also pointed out by another Reviewer. We edited the sentence to: "The anisotropy is defined as the departure from Lambertian scattering (isotropic), caused by the physical structure of media through which photons pass."

7. Line 90-105: When reviewing surface reflectance products, this manuscript should not omit another important operational normalized surface reflectance products-MCD43 NBAR, and as well as the related anisotropy products-BRDF (MCD43A1 etc.), due to its acceptance in land applications all over the world.

Addressed in revision: We agree. Another reviewer has also pointed this out. To address this concern, we edited the sentence to: "By mitigating atmospheric interference and advancing the accuracy of surface reflectance over tropical vegetation by a factor of 3 to 10, MAIAC offers substantial improvement over conventional products such as the MOD09 (Hilker et al., 2012). Because of the better data quality retrieval, MAIAC is also an alternative to the MCD43A4 16-day Nadir Bidirectional Reflectance Distribution Function (BRDF)-Adjusted Reflectance (NBAR) product due to the less variable seasonal signal (3 to 10 times) over evergreen forests resultant from reduced effects of sun-view geometry. While the MCD43A4 NBAR product offers view-illumination correction, using the MAIAC products one can also correct for solar illumination effects at the same time."

8. Line 90: What does it mean “a factor of 3 to 10” on the accuracy?

Addressed in revision: It means the MAIAC signal had 3 to 10 times less signal variability than the traditional MODIS products over evergreen forest landscapes. The MAIAC product with additional corrections and cloud filtering than the traditional products produced more stable results over time. To clarify this in the manuscript, we edited the sentence in the Introduction, as showed in the previous response.

9. Line 280: “to demonstrate the spatial and temporal distribution of…”?

Addressed in revision: We assume the sentence was not clear or there was an issue with the wording. To clarify, we edited the sentence to: “We selected three experimental areas at the Brazilian Amazon rainforests to show the spatial and temporal distribution of NAD and ANI data (rectangles in Figure 1).”

10. Line 239-251: Gb, Tb? bit or Byte?? Check it through the whole text.

Addressed in revision: We edited all occurrences of ‘Gb’ and ‘Tb’ and changed to ‘GB’ and ‘TB’ throughout the manuscript. We also added the names gigabytes and terabytes in parenthesis to clarify that in the first occurrence of each.