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 #3 – RC3

The manuscript "AnisoVeg: Anisotropy and Nadir-normalized MODIS MAIAC datasets for satellite vegetation studies in South America" by Dalagnol et al. describes the production of a data set on vegetation anisotropy derived from MODIS data for South America. There is considerable potential for such a data set to provide useful information about the state of the land surface, and one tantalising hint that the authors provide is the result that the ANI is able to explain R2=0.55 of the variability in the GEDI canopy height signal (Fig 5., c.f. R2=0.16 for the normalised reflectance). Overall, I think this is a well written paper which describes a potentially important data set. I do have a few grumbles, mostly minor, but I hope the authors take these in the spirit in which they are intended – I am only seeking to improve the manuscript, and I am not suggesting any complex changes.

Addressed in revision: Thanks for your time to read and give comments about the manuscript. We hope to have answered most of your questions and incorporated the feedback.

Main comments:

I find it strange that MCD43 isn't mentioned anywhere. The implicit claim is, I assume, that the MODIS MAIAC data is far superior to the MOD09 and MY09 which is used to derive MCD43. I don't disagree with this, but one could also use the MCD43 data to produce similar data (not to mention that MCD43A4 contains an NBAR product which is similar in concept to the NAD in this paper). Some discussion of this in the introduction is necessary.

Addressed in revision: This is a good point and oversight from our part. We mentioned some advantages of MAIAC, including the better cloud masking and increased clear-sky observations, but did not include the traditional MODIS product name. This was fixed by including MCD43A4 name to the text and extending a bit explanation of the product's differences. The updated text now reads:

"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."

Fig 3 does not convince me that there is complimentary information in the NAD and ANI data. Some additional metric to show how much different information is in there would be useful. For example, if

the authors calculated the principle components, how much variance would the second component explain? [note – I am convinced of this by some of the later results, but I it should ideally be demonstrated here too.]

Addressed in revision: Indeed, the figure does not quantify how complementary the information is, but show qualitatively that NAD dataset has similar values amongst the three landscapes while ANI varies from lower values at lower AGB to higher values at higher AGB. This is what we wanted to show in this part of the manuscript. As the reviewer mentioned, later on we quantify the relationship of each one to forest structure and that gives a more robust answer to this question.

L409: Table 3, captions says: "Examples of other multi-angular anisotropy indices that can be further calculated using layers of the AnisoVeg product." Initially I thought this wasn't possible as earlier the manuscript gives the impression that the layers are only ANI and NAD, however I see now this isn't the case. I suggest including a table explaining what the actual layers of the AnisoVeg product are. On a related note, although the authors call "H" the hotspot in this part of the paper, the algorithm apparently doesn't compute the value in the hotspot direction and instead use 35 degrees (see Line 217 - and I agree this is a sensible thing to do). The authors should only call this "back-scattering" so as not to give the wrong impression – it is not in the hotspot.

Addressed in revision: That is a good point. To clarify that in the manuscript, we chose not to include an additional table - because we already have too many figures and tables - but we updated the paragraph that explains what the product is with additional information:

"The AnisoVeg product consists of two main types of data spanning from 2000 to 2021 in monthly composites at 1-km spatial resolution: (a) the nadir-normalized (NAD) data; and (b) the anisotropy (ANI) data. Each data type has 10 layers corresponding to the MODIS bands 1 to 8, and two VIs (NDVI and EVI). Additionally, the product provides auxiliary layers of backward scattering and forward scattering, including part of the bands (description on section 5)."

We agree with the reviewer that the hotspot and darkspot were misleading. To clarify that, we changed the letters from H to B for backward scattering and from D to F for forward-scattering, and removed mentions to hotspot and darkspot.

Minor comments:

L59 – I think this sentence could cause confusion between what the definition of anisotropy is, and what causes it. Anisotropy is defined as the departure from Lambertian scattering, it is caused by the physical structure of media through which photons pass. I am certainly not doubting that the authors know this, but I think it could be made clearer to the reader. I am also not sure about the use of the word "mechanical" in this sentence.

Addressed in revision: Agreed. We took the liberty to use and edit upon the sentence provided by the reviewer, which is clearer than the previous one. The sentence now reads: "The anisotropy is defined as the departure from Lambertian scattering (isotropic), caused by the physical structure of media through which photons pass."

L73 – the Foody and Curran reference is a bit of an odd one to include to support this statement. Their paper doesn't really look at the influence of biophysical properties on the surface anisotropy, although it does include a correction for the influence of terrain on the observed radiance. With no disrespect to

either Foody or Curran, there are many more relevant papers that could be included here. Suggest finding some different references.

Addressed in revision: To address this concern, we replaced the reference by Sims et al. (2011) and Galvão et al. (2004) references that explored the effects of sun and view angle on vegetation indices variability:

Sims, D. A., Rahman, A. F., Vermote, E. F., & Jiang, Z. (2011). Seasonal and inter-annual variation in view angle effects on MODIS vegetation indices at three forest sites. *Remote Sensing of Environment*, *115*(12), 3112–3120. https://doi.org/10.1016/j.rse.2011.06.018

Galvao, L. S., Ponzoni, F. J., Epiphanio, J. C. N., Rudorff, B. F. T., & Formaggio, A. R. (2004). Sun and view angle effects on NDVI determination of land cover types in the Brazilian Amazon region with hyperspectral data. *International Journal of Remote Sensing*, *25*(10), 1861–1879. https://doi.org/10.1080/01431160310001598908

L110 – Again, I do not think the Foody and Curran reference is the best choice of references here. The totality of what it says on this subject is: "Terrestrial land cover surfaces are typically non-Lambertian reflectors and may exhibit a class- specific angular reflectance response. Thus data acquired at different angular geometries may help to identify and characterize land cover classes in both optical (Barnsley, 1994) and microwave (Foody, 1988) wavelengths." Whereas the current manuscript attributes "the use of multi-angular information to obtain metrics of anisotropy and extract information on forest structure" to that paper. I think this is a bit of a stretch. Suggest finding some different/additional references.

Addressed in revision: The reviewer is correct. We brought two new references to substitute the one from Foody and Curran.

Diner, D. J., Braswell, B. H., Davies, R., Gobron, N., Hu, J., Jin, Y., Kahn, R. A., Knyazikhin, Y., Loeb, N., Muller, J. P., Nolin, A. W., Pinty, B., Schaaf, C. B., Seiz, G., & Stroeve, J. (2005). The value of multiangle measurements for retrieving structurally and radiatively consistent properties of clouds, aerosols, and surfaces. *Remote Sensing of Environment*, *97*(4), 495–518. https://doi.org/10.1016/j.rse.2005.06.006

Gobron, N., Pinty, B., Verstraete, M. M., Widlowski, J. L., & Diner, D. J. (2002). Uniqueness of multiangular measurements - Part II: Joint retrieval of vegetation structure and photosynthetic activity from MISR. *IEEE Transactions on Geoscience and Remote Sensing*, *40*(7), 1574–1592. https://doi.org/10.1109/TGRS.2002.801147

L113 Whilst the Sandmeier et al., 1998 reference is appropriate here, it is most definitely not the "first" example of this type of work. It is an early example though, and perhaps that would be a better way of describing it.

Addressed in revision: The reviewer is correct. We edited the sentence to more accurately represent what Sandmeier et al 1998 have done in their study: "One of the early experiments exploring the use of anisotropy to extract information about vegetation structure were conducted by calculating the ratio between backward and forward scattering data and generating the anisotropy index (ANIX) on studying short-stature grass-type vegetation (Sandmeier et al., 1998)."

L179 Another strange reference. The Lucht and Lewis paper refenced presents a really nice results around the so-called "weights of determination" of the kernel BRDF models, but as a general reference for the RTk-LSp model it is an odd choice. A more obvious paper would be, for example, Wanner et al. (1995).

Addressed in revision: Agreed. We substituted that reference for Wanner et al., 1995.

L184: Eqn 1 – why are the labels for the kernel weights superscripted (e.g. kv) and the kernel values subscripted (e.g. Fv)? Ultimately, it doesn't greatly matter, but it would be better if these were made consistent, unless there's a good reason for not doing this.

Addressed in revision: We followed the way the subscript and superscript are organized for the parameters in Lyapustin et al 2018. We would prefer to keep them that way.

L184: Eqn 1 – I find it odd that the with kernel values are given the symbol "F" and the kernel weightsare given the symbol "k". Traditionally in the literature it has been the other way around see, for example Wanner et al. (1995) or, indeed, Lucht and Lewis (2000). This tripped me up whilst reading the paper, and a later statement appeared wrong to me due to this, so it could cause confusion. I strongly suggest changing this so that it adheres to the convention.

Addressed in revision: We can understand the confusion, but we basically followed the same convention presented in Equation 1 of Lyapustin et al 2018 and other papers related to MAIAC. Since those use the same convention, we would prefer to keep them consistent to each other, even though it deviates from the previous nomenclature from literature e.g. Wanner et al.

L200: "0.009107388 degrees" – this is quoted too precisely - 0.000000001 of a degree is a fraction of a millimetre. The text goes on to say that it is "approximately equivalent to 1 km" so really only needed to quote to that precision (say 4 or 5 d.p. in degrees).

Addressed in revision: Good point. We changed the value to 0.0091.

Typos etc:

L98 product -> products

Addressed in revision: Corrected.

L205: Here an astrix has been used as a multiplication sign, whereas in Eqn 1. an actual multiplication sign was used. Suggest making consistent.

Addressed in revision: Corrected. They are all multiplication signs now.

L315 "The EVINAD and EVIANI are seasonal variability and…" this doesn't scan. Should it say "The EVINAD and EVIANI are seasonally variable and…"?

Addressed in revision: The reviewer 1 also pointed this out. It is now corrected.

References:

Wanner, W., Li, X. and Strahler, A.H., 1995. On the derivation of kernels for kernelâ€• driven models of bidirectional reflectance. Journal of Geophysical Research: Atmospheres. 100(D10), pp.21077-21089.