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Atmospheric Measurement Techniques Discussions

Interactive comment on “A geometry-dependent surface Lambertian-equivalent reflectivity product at 466 nm for UV/Vis retrievals: Part I. Evaluation over land surfaces using measurements from OMI” *by* Wenhan Qin et al.

Anonymous Referee #1

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The manuscript by Qin et al. presents the generation and test of a geometry-dependent Lambertian-equivalent reflectivity (albedo) product. This ‘GLER’ product is derived from MODIS products that characterize the surface reflectance anisotropy at high spatial resolution. The purpose is of the GLER-product is to replace the conventional approaches making use of a viewing-geometry independent LER, starting with OMI. Now that the spatial resolution of sensors such as OMI, TROPOMI and upcoming geostationary instruments is becoming better than 10 km, the effects of surface reflectance anisotropy are increasing in relevance and (also) need to be accounted for in satellite

retrievals from TROPOMI and TEMPO, GEMS, and Sentinel-4.

The paper is generally well written, but a bit long (and are the 40 scatterplots really necessary?). The thorough introduction to the topic is valuable, as well as the good and useful references. The test of the GLER product against the OMI LER and the standard viewing-geometry Kleipool et al. [2008] climatology over different regions and years is solid. I very much appreciated that the authors reiterated the point that a consistent approach for surface reflectivity should be taken for both cloud and trace gas retrievals, as the latter depend on consistently derived cloud information. This is not always done. There are OMI NO2 products around that use BRDF-parameters for calculating the clear-sky AMFs and then a LER for the clouds, and such inconsistencies lead to avoidable systematic errors in the data product.

I have a two main concerns that I feel should be addressed.

1. Darker MODIS than OMI scenes

The authors make a deliberate choice to generate a GLER product based on measurements from another instrument (MODIS) than the product will be used for (OMI). This is understandable since kernel coefficients describing surface reflectance anisotropy are not available from the OMI sensor itself. The drawback however is that the GLER product is based on a set of very different viewing conditions, geometries, assumptions on the state of the atmosphere, and instrument specifics. All these inconsistencies can make the GLER product potentially less suitable for application on OMI retrievals. The authors are surely aware of this, and discuss some of these differences (such as the higher probability that the larger OMI scenes have been influenced by residual clouds and aerosols), but provide too little information on others. Since the MODIS-based GLER is proposed as the preferred ancillary dataset for future NO2 and O2-O2 cloud retrievals, we need to learn more about the (hopefully good) representativeness of the MODIS-based data for the OMI scenes. The MODIS atmosphere-corrected BRDF coefficients are crucial in this sense, and we need to obtain confidence in the GLER product. Yet the atmospheric correction for the MCD43 product is hardly discussed (only briefly on page 5). While some relevant papers are cited, it is unclear how the MCD43 product accounted for the presence of clouds, aerosols, and atmospheric pressure. The authors should

a. explain how the atmospheric correction was done, and

b. how the correction and/or the MODIS data screening may have led to an ensemble of (MODIS) scenes that is generally 'darker' than the OMI scenes.

Without such clarifications, it remains misty whether allegedly "small calibration differences" between MODIS and OMI could explain the differences between the GLER and LER, and whether the MODIS-based GLER product is actually so suitable as claimed by the authors.

2. Water model

For inland waters, ocean models are used, but the manuscript remains vague on how the water reflectance anisotropy is accounted for in the approach. The authors should provide a mathematical description of how the GLER is computed for ocean scenes. The Appendix A doesn't cut it, as only ancillary data used to calculate the surface reflectance anisotropy rather than the actual formulas are given.

Specific comments:

P3, L2-4: the point that surface anisotropy effects are more relevant in NIR than in the VIS was prominently made in Lorente et al. [AMT, 2018], and it would be appropriate to cite that paper here.

P5, L22-25: it is not clear why the authors include the phrase about the use of both morning and afternoon MODIS sensors, since this is not 'aan de orde' in the manuscript.

P5, L26-34: can the authors be more quantitative here and state the quantitative find-

ings from the albedo validation exercises? Any indications for the MODIS albedo being biased low or high? What were the "accuracy requirements" exactly?

P7, suggest to move Figure 2 to the Supplement. I think the readers can trust the experienced NASA-team to do a proper job in re-gridding, and there is no new science in here.

P8, L6: please clarify what "day-1 solar irradiance spectrum" refers to. Is it the irradiance spectrum measured on 1 October 2004?

P9, Figure 3 also appears redundant. I don't see why these (quite common) re-gridding approaches should be discussed in detail. The figure looks to me as a mere illustration of the approach described in Haines et al. [1994], so I'm afraid nothing's new here.

P10, L10-12: it is unclear how application of a pseudo-spherical geometry calculation can lead to a "sphericity correction for both incoming and outgoing viewing directions". Please discuss this in more detail. How does the supposed spherical correction relate to the pseudo-spherical correction only?

P10, L19: in Eq. (2) and from the text below it is not immediately clear that Icomp refers to the VLIDORT-simulated TOA radiance levels based on simulations with a pure Rayleigh atmosphere and the capacity of the model to account for the surface BRF. Then, R can only be found if the model can simulate I0, T, and Sb, something that VLIDORT surely can, but is not becoming clear from the text.

P11, L26-27: it would be appropriate to cite papers here that made the point that cloud fraction retrievals actually provide 'effective cloud' fraction information that accounts for aerosol effects, e.g. Boersma et al. [2011], and for higher scattering in the forward direction of cloud particles, e.g. Lorente et al. [2018].

P11, L31: suggest to clarify that "this equation" refers to Eq. (2).

P13, L1-5: can you provide a quantitative statement on how much OMI LER is typically higher than GLER? From the intercepts one would say the difference is 0.01, but possibly the mean or median difference is a more meaningful metric. I would also encourage if the authors could report whether there is a pattern in how the LER-GLER differences change between different regions/surface types.

P15, L12-14: the hypothesis that localized floodplains darken after rain resulting in a signal detected by OMI LER (daily data), but not by GLER (MODIS-based 8-day data) needs to be substantiated. It sounds possible, but there is no basis for this statement from a result shown.

P16, L5-7: it is possible that OMI data is indeed affected by residual clouds or aerosols leading to higher reflectances. But it is also possible that the MODIS-based data have been overcorrected for atmospheric effects. As long as no evidence is presented to obtain confidence in the validity of the atmospheric correction (and data screening) applied to the MDC43 suite, we cannot know if it's one or the other, see my main concern.

P19, L8-10: please explain how using the GLER reduces the tropospheric AMF. Is it via the increased cloud fractions (more screening), or the lower clear-sky AMFs because of the darker surface, or both?

P19, L20: please clarify how differences in calibration between MODIS and OMI could explain the bias of 0.01 between OMI LER and GLER. Is there any reason to believe that OMI is calibrated such that it detects too low, or MODIS too high reflectances? Have level-1 data been compared in the first place?

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