

Atmos. Meas. Tech. Discuss., referee comment RC3
<https://doi.org/10.5194/amt-2020-502-RC3>, 2021
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Comment on amt-2020-502

Anonymous Referee #1

Referee comment on "Directionally dependent Lambertian-equivalent reflectivity (DLER) of the Earth's surface measured by the GOME-2 satellite instruments" by Lieuwe G. Tilstra et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2020-502-RC3>, 2021

This work is a great addition to the currently available angular dependent LER products that have considered surface BRDF effects based on the LER concept. It provides important improvements to the author's previous LER climatology product based on GOME-2 observations, which include directional LER (DLER) at as many as 26 wavelengths from 328 to 772 nm. It fits well to the scope of AMT and should be considered publishing after addressing the following issues.

1. Although bidirectional reflectance distribution function (BRDF) mathematically describes the scattering of a parallel beam of incident light from one direction in the hemisphere into another direction in the hemisphere, the BRDF itself, as a ratio of infinitesimals, is a derivative with "instantaneous" [in angle] values that can never be measured directly, as stated in Nicodemus et al. (1977).

Therefore, it seems more proper to use BRF or simply reflectance in many places throughout the manuscript when referring to directional reflectance datasets. BRF (Bidirectional Reflectance Factor) is defined as the ratio of the radiant flux reflected by a surface to that reflected into the same reflected-beam geometry by an ideal (lossless) and diffuse (Lambertian) standard surface, irradiated under the same conditions.

So in remote sensing community, BRF is commonly used to describe the reflectance factor calculated from either ground measurements or satellite observations that have finite field-of-view (FOV). The authors can refer to Schaepman-Strub et al., (2006) for more details regarding use of BRDF and BRF.

The suggestion here is to only keep BRDF before 'model', 'parameter', 'product', 'database' etc (i.e., only use it as an adjective) and replace BRDF with BRF in other places when referring to directional data set itself, such as at line 9, 11, 14 in page 1, as well as

many instances in the rest of the manuscript.

2. It seems not proper by calling LER (defined in Eq.2) as albedo (see line 21, page 3) because albedo is defined as the ratio of the radiant flux reflected into the whole upper hemisphere (i.e., the integral from all viewing angles) to the incident radiant flux. In other words, albedo is independent of viewing directions, but LER does for a non-Lambertian surface. That is the physical basis for DLER in this study, GE_LER (Loyola et al., 2020) and GLER (Vasilkov et al., 2017). Also as shown in Eq.3, LER has the same unit as R.

3. The authors should mention in the figure caption that Fig.1b only applies to land surfaces because reflection from a non-Lambertian surface, in general, could have another peak in the forward scattering direction, i.e., specular (mirror) reflection over snow/ice or water surfaces (so-called sunglint) in addition to the hot spot peak (retroreflection) over rough surfaces like vegetation due to shadow hiding.

4. The authors should provide reference(s) to justify the use of a parabolic function to simulate directionality of surface reflection for vegetated surfaces as shown in Eq.5. There have been many publications from BRDF modeling community in land remote sensing that demonstrated such parabolic function only applies to non-vegetated surfaces such as desert or bare soil. That's why in MODIS BRDF products, a linear combination of different kernels is used to describe surface directional reflection in general as described by Eq.6.

5. The title of section 3.1 should be changed to 'MODIS BRDF model'.

6. Though I believe DLER is derived from the real GOME-2 measurements as mentioned in the 2nd paragraph (lines 9-14, page 4) of section 2.2, it also says DLER product is based on simulated TOA reflectances with DAK (line 23, page 6), That would create some confusion for readers and should be clarified.

7. Since real GOME-2 observations are used to derive DLER, it is not clear how the aerosol and cloud contaminated data is removed and the data screening criteria used. How data gaps (due to aerosol and/or cloud contaminations) are handled? All these need to be addressed in the manuscript.

8. It looks like DLER product only has five viewing direction bins since the data is sorted out through five sub-containers (see line 12, page 4). What are the exact angular widths for these five bins, any justification that these five angular bins can adequately describe the angular distribution of GOME-2 measurements? What is the angular resolution in the GOME-2 x-track scan positions and is that the basis for selecting the five view angle bins? All these need to be deliberated a little more.

Since this is not a full consideration of BRDF effects but a rough approximation, it should be said so in item 5 of page 10 (lines 22-23).

Although this approximation may work for not too large SZAs where the angular width of the hot spot is pretty broad. However, when SZA is high (e.g., larger than 45 deg), the hot spot width becomes very narrow. In such situation if GOME-2 viewing angle falls into the hot spot region, the peak will be smoothed out by the large angular bin as shown in figure 1b, resulting in much smaller DLER value. Same is true for the sunglint effect over ocean should this five viewing angle scheme be applied to water surfaces,

9. Fig.7 shows results at 772 nm. Readers may also be interested to see results for short wavelengths (e.g., 363, 380, 340 or shorter) since some of the short wavelengths in Table 1 are widely used in trace gas retrieval based on UV/VIS data such as ozone, NO₂, aerosol via aerosol index and clouds via O₂-O₂ or rotational Raman scattering algorithm.

10. For Figs. 8-9, DLER from 645 nm is compared with MODIS band 1. Can the authors show comparisons with the shortest wavelength in MCD43C2 product like band 3 (centered at 470 nm)? Though the difference would be larger as expected, readers may be interested to see how DLER and MODIS BRF follow with each other in angular distributions.

References

Nicodemus, F. E., et al. (1977). Geometrical considerations and nomenclature for reflectance. Washington, DC: National Bureau of Standards, US Department of Commerce. URL: <http://physics.nist.gov/Divisions/Div844/facilities/specphoto/pdf/geoConsid.pdf>

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