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Reply on CC1

Lieuwe G. Tilstra et al.

Author 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-AC3, 2021

Dear Dr. Loyola,

Thank you for placing a community comment on the AMT discussion site.

The point that you are raising has also been raised by Reviewer #3 in RC1.

We have rewritten this part of the Introduction, making a more clear distinction between the three approaches, and highlighting the differences. The text now reads:

" Recently, several different approaches have been introduced to address this issue. One example is the introduction of geometry-dependent surface Lambertian-equivalent reflectivity (GLER) [Vasilkov et al., 2017; Qin et al., 2019]. In the GLER approach, surface BRDF information from the MODIS surface BRDF database [Gao et al., 2005] is used to calculate Lambertian surface albedo at 466 nm for land-covered satellite footprints of the OMI instrument. The result is a Lambertian surface albedo, ready to be used in a radiative transfer code with Lambertian surface reflection, calculated for the exact scattering geometry of the OMI footprint and for the specific date of the OMI footprint. The advantage is that this Lambertian surface albedo is adjusted to the geometry of the observation, whereas the surface albedo available in the typical Lambertian surface albedo climatologies is more representative for the minimum value of the surface reflectivities that were observed [see e.g. Lorente et al., 2018; Liu et al., 2020] – and therefore underestimates the surface albedo for many of the scattering geometries. The disadvantage of the GLER approach is that it, at least for land-covered scenes, depends fully on the MODIS surface BRDF database. This limits the spectral usage to the seven wavelength bands of the MODIS BRDF product. For the retrieval of NO2 and of cloud properties from the O2-O2 band, both performed in the spectral regime close to 466 nm, this is not a problem – but for many other retrievals it is.

A second example of a geometry-dependent surface LER database is the geometry-dependent effective Lambertian-equivalent reflectivity (GE_LER) database introduced in a recent paper by Loyola et al. [2020]. The GE_LER approach does not depend on external data such as MODIS BRDF and uses machine learning techniques to retrieve the surface reflectivity from level-1 data of the sensor (GOME-2, TROPOMI, or another UVN sensor). Like the GLER, the GE LER provides daily maps of the surface properties. Unlike the GLER, the GE LER provides information for all surface types (land, ocean, snow/ice) and covers the UV-VIS-NIR spectral region.

In this paper we introduce the directionally dependent Lambertian-equivalent reflectivity (DLER) of the Earth's surface derived from GOME-2 observations. The surface DLER is retrieved as a function of the viewing geometry and therefore describes the anisotropy of the surface reflectivity. The DLER approach is very different than the GLER approach in that we perform a retrieval directly on GOME-2 level-1 data, not relying on BRDF input (or any other input) from an external database. In this way the wavelength bands, 26 in total, can be chosen freely, allowing the resulting DLER database to support the retrieval of most atmospheric species. A difference compared to the GLER and GE LER databases is that the directional dependence of the DLER is provided as a parameterisation of the viewing angle. It is not mapped on a satellite footprint and serves as a climatological dependence. The directional approach of the GOME-2 surface DLER is therefore applicable to all polar satellites with equator crossing times close to that of GOME-2 (09:30 LT). This includes satellite instruments like GOME and SCIAMACHY, GOME-2 itself, and the future Sentinel-5/UVNS instrument scheduled for launch in 2023.

Like the GLER and GE LER, the DLER is a Lambertian property and therefore can be used in situations where radiative transfer calculations include Lambertian surface reflection. .... "