Review of "MICRU background map and effective cloud fraction algorithms designed for UV/vis satellite instruments with large viewing angles" by Sihler et al.

The manuscript describes a model for accounting for anisotropic reflection of solar light from Earth's surface in an effective cloud fraction algorithm designed for UV/Vis satellite instruments. Results of the application of the algorithm to GOME-2 data are compared with other cloud fraction algorithms. Appendices provide technical details of the developed algorithm. The manuscript is clearly relevant for AMT. Even though the material is not a significant advance in remote sensing of clouds it could be published to document the GOME-2 cloud fraction algorithm in the literature. The abstract provides a concise and complete summary of the paper. The earlier work is properly credited. I recommend publication of this manuscript only after major revisions which address the following comments.

General comments

1. The authors do not clearly state what are the main improvements of the proposed algorithm as compared with the existing cloud algorithms which also accounts for surface BRDF. It would be useful to summarize those improvements in Conclusions.
2. Low values of LER are of the primary interest for the construction of a minimum LER map (background map) which is the core of the developed algorithm. The existing surface reflectance data sets (see e.g. Kleipool et al., 2008) show that an overwhelming fraction of Earth's surface has reflectance lower than 0.1-0.15 in the UV/Vis spectral range with wavelengths shorter than 500 nm. This spectral range is most important for trace-gas retrievals. The background map is constructed using a look-up table that relates top-of-the-atmosphere radiance and LER. Table 4 lists the nodes of this look-up table. The step of 0.1 in LER nodes in Table 4 is quite insufficient for calculations in the low LER range. Any interpolation with so sparse nodes would lead to high errors in the low LER range thus in the minimum LER map. The authors should add more nodes of LER for its low values and provide an estimate of interpolation errors. The paper cannot be recommended for publication without addressing this comment.
3. In Appendix C, the authors consider the spectral dependence of BRDF model parameters. Those internal parameters are used to build the minimum LER map. It would be useful if the authors would consider the spectral dependence of the final product of the developed algorithm, namely the effective cloud fraction. There is some contradiction in interpreting the spectral dependence of the effective cloud fraction. Formally, the effective cloud fraction is wavelength dependent because it is defined by

spectral quantities (Stammes et al., JGR, 2008). However the radiative transfer simulations show that the cloud fraction is nearly invariant with wavelength over a wide spectral range (Gupta et al., AMT, 2016).

4. I strongly recommend to show and analyze the cross-track dependence, i.e. dependence on VZA, of the cloud fraction. Accounting for BRDF effects on the cloud fraction would flatten the cloud fraction cross-track dependence reducing possible biases related to not accounting for anisotropic reflection of solar light from Earth's surface. Particularly, it is important for the ocean where the sun glitter can significantly affects cloud pressure retrievals. The authors are encouraged to compare their results with those in the following paper:

Fasnacht et al., A geometry-dependent surface Lambertian-equivalent reflectivity product for UV-Vis retrievals – Part 2: Evaluation over open ocean, Atmos. Meas. Tech., 12, 6749–6769, 2019.

5. In my opinion, the manuscript is too long and somewhat overloaded with technical details. More technical details could be moved in Appendices. For instance, Section 2.3.2 can be either cut down or moved to an appendix. Section 4 returns to Fig. 8-20 which were already discussed in the previous section. I would recommend to combine Sect. 3 and Sect. 4 to avoid possible duplication.

Specific comments

The title does not clearly reflect the contents of the paper. MICRU is not a common acronym. It is not clear what "background map" means. The title does not reflect that the paper is dealing with accounting for anisotropic reflection (BRDF) of solar light from Earth's surface in cloud algorithms.

P.6, L4 and elsewhere. The letter T is commonly used to denote the transmittance in radiative transfer. To avoid confusion it is desirable to select a different symbol for LER.

P.10, Fig.4. T_min in the figure capture is not defined yet.

P.11, L.1. It is not clear how the land sea mask is applied to a nominal GOME-2 pixel? Is a land/sea fraction within a pixel known? Please clarify.

P.11, L.7. Please provide a reference to GTOPO30.

P.11, L.26. Please specify the wavelengths at which the absorbing aerosol index is defined. Its threshold value used for filtering the data depends on the wavelengths.

P.12, L.3. While doing RT computations in a spherical atmosphere the authors do not account for the atmospheric refraction. Please provide a justification for neglecting the refraction effect?

P.12, L.5. The use of a single value of 250 DU for total ozone column may not be sufficient for wavelengths within the Chappuis absorption bands in case of high solar zenith angles (Table 4 lists the angles up to 87 deg.).

P.14, L.6. Why is the glitter reflectance, r_g, defined as an independent variable? It depends on the sun-view geometry, e.g. on the viewing zenith angle which is specified as an independent variable. Please clarify.

P.19, L.23-24. The authors say " Longer time-series increase the probability of including measurements not contaminated by clouds." Please provide actual numbers that characterize the duration of time-series.

P.22, L.4. Please give a reference to FRESCO v8.

P.24, l.21-22. Fig. 8(f) shows the minimum LER residuals, T_min (stated in Line 14). However, the authors say that "… average deviations much smaller than 0.04, which is the targeted accuracy of MICRU CF". Please clarify how the LER residual of 0.04 is related to the targeted accuracy of cloud fraction.

P.25, L.2. In the discussion of Fig. 9, CF is mentioned. Please clarify what parameter (LER or CF) is shown in Fig. 9.

Section 3.2 compares cloud fractions from different algorithms. Please specify the wavelengths at which the cloud fractions are retrieved. Can the observed differences between MICRU and FRESCO/OCRA CF retrievals be due to the wavelength difference?

Section 3.3.2. Please explain why there are CF differences retrieved at different wavelengths for high values of CF. For high values of CF, possible surface effects could be neglected. Given the cloud backscatter spectrally independent, the CF values at different wavelengths seem to be same.

Section 3.4.1. What is a conclusion of the comparison of MICRU and OCRA? Do the authors attribute the differences between the algorithms to the different treatment of surface BRDF?

P.31, L.6. "… different definition of the upper threshold." What do you mean? What is the upper threshold for OCRA?

Section 3.4.2. Please formulate a purpose of comparing MICRU with three versions of FRESCO. Why do not select just the latest version of FRESCO?