Dear Editor, dear reviewer,

Thanks for the valuable comments, which help to improve the quality of the paper. The detailed replies are addressed below point by point in blue.

Best regards,

Linlu Mei on behalf of all co-authors

GENERAL COMMENTS

The article aims at describing the improvements of the cloud and aerosol database of SCIATRAN software package. A precise description of the optical properties of cloud and aerosol is an important part of a radiative transfer package. The article gives a good overview of this database. The new features are well distinguished. The article presents a scientific interest and is worth being published in GMD. However, some points could be improved:
- To avoid the need to refer to external articles, it would have been preferable to give some more details on the components of CAS, which have not been updated. Of course, if wouldn't be necessary to delve into the details, since they are available in the references.

Response: The components of CAS which have not been updated include

Cloud:

- liquid water clouds with effective radius of water droplets in the range 4 – 20 µm
- ice clouds consisting of ice crystals having the shape of second generation fractal

Aerosol:

- OPAC version 3.0
- WMO
- LOWTRAN

Surface:

- RPV

- modified RPV models
- RTLSR model

An extended description for the above listed components is included in the revised version (See Appendix B in the revised version).

- It would have been interesting to have more comparisons of modelizations done with the new version of SCIATRAN/CAS with former versions and with other modelizations or measurements.

Response: Some comparisons for the updated and old versions of CAS databases are included in the revised version of the manuscript. In particular, the comparison between OPAC version 3 (former version) and OPAC version 4 (new version) databases.

- Even if the acronyms are properly defined throughout the text, it seems to me that it would be more easy for the reader if they were gathered in an appendix.

Response: A list of acronyms is included in the revised version (See Appendix A in the revised version).

SPECIFIC COMMENTS

Lines 41 to 52 about the use of SCIATRAN do not seem necessary to me, as well. The same applies to figure 1.

Response: In the revised manuscript, we have removed Fig. 2 and rewritten this section to provide only the fundamental-needed information about SCIATRAN applications. As to Figure 1, we would prefer (if it is also OK from reviewer side) to keep it since this is the first overview figure of SCIATRAN users after 33 years developments. We believe Figure 1 will still provide information especially for new users to get more confidence to join the SCIATRAN community.

Lines 94 and 95, it is said that the calculation can be performed 175.44 nm to 40 micrometer.

Response: Different models and databases are valid in different spectral ranges. In the spectral range 225 – 2500 nm most of the described databases can be used. For gaseous absorbers, Rayleigh scattering and thermal emission, the calculations can be performed in the spectral range 175.44 nm – 40 µm. We have updated the description in the revised version (see lines 66-69 in the revised version)

Lines 99 and 100, it is mentioned that aerosol and cloud scattering can be taken into account.

Response: Yes, aerosol and cloud scattering could be considered in all previous SCIATRAN versions. However, in V4.6, we have largely extended available databases for aerosol and clouds.

However, line 180 and 181, it is said that database can be used "at least" between 225 nm and 2.5 micrometer. Is seems to me that there is a contradiction there: is it possible to model aerosols and clouds between 175.44 and 225 nm, and between 2.5 and 40 micrometer or not ? This point should be made clear in the article.

Response: Different models and databases are valid in different spectral ranges. In the spectral range 225 – 2500 nm most of the described databases can be used. For gaseous absorbers, Rayleigh scattering and thermal emission, the calculations can be performed in the spectral range 175.44 nm – 40 μm. We have updated the description in the revised version (see lines 66-69 in the revised version)

Line 111, it would be interesting to specify with jacobian can be computed (derivative of radiances with respect to which variables ?)

Response: For CAS related parameters Jacobians can be calculated for the cloud optical thickness, cloud top and bottom heights, effective radius of water droplets and ice crystals, aerosol number density, surface albedo, etc. The complete list of atmospheric and surface parameters, for which the Jacobians can be calculated, can be found in the user guide. This information is also included in the revised manuscript (see lines 88-90 in the revised version).

Line 118, I understand that the goal of the paper is not to delve into details which have been extensively covered in other papers, but the list of the solvers which can be used should be precised.

Response: The information about solvers is included in the revised manuscript (see lines 97-102 in the revised version).

Line 187: by "optical characteristics" do you mean refractive indexes or (SSA, extinction coefficient and phase function?)

Response: Optical characteristics are referring to the extinction coefficient, single scattering albedo and scattering matrix (or phase function in the scalar case).

We have clarified it in the revised manuscript (see lines 176-177 in the revised version).

Line 205: it could be interesting to give references for OPAC version 3. This could also be done in section 4.1.1, event if the details have been given in [Rozanov, 2014]

Response: Reference for OPAC version 3 (Hess et al., 1998) is added in the revised manuscript.

M. Hess, P. Koepke, and I. Schult. Optical properties of aerosols and clouds: The software package OPAC. Bulletin of the American Meteorological Socie, 79:831 – 844, 1998

Section 4.1.1 : it could be interesting to give references for OPAC version 3. This could also be done in line 205, even if the details have been given in [Rozanov, 2014]

Response: Reference for OPAC version 3 (Hess et al., 1998) is added in the revised manuscript (see above)

Line 205-212: I understand that the refractive indexes and size distributions from OPAC are used to compute the topical properties of an aerosol type. Why not use directly optical properties (i.e. SSA, extinction coefficients and phase function) from OPAC?

Response: There are two reasons:

i) the database containing refractive indices and size distributions is significantly more compact in contrast to the database containing SSA, extinction coefficients and phase function;

ii) the OPAC database does not provide all elements of scattering matrix. As described in Hess et al (1998), to avoid repeated Mie- or ray-tracing calculations, optical properties of basic aerosol components and clouds are stored in OPAC, the optical properties are the extinction coefficient, the scattering coefficient, the absorption coefficient, the volume phase function, the single scattering albedo and the asymmetry parameter.

Line 218-225: it is mentioned above that the optical properties are computed from the refractive indexes. Here, it is said that they can be set for different altitudes. Does it mean that optical properties can either be directly specified or computed from refractive indexes ?Even if OPAC v3 is not the focus of this paper, the way optical properties are defined (specified or computed from refractive indexes) should be precised.

Response: In the case of OPAC V3.0, the aerosol optical properties are computed using refractive indexes and size distributions from the database. The calculations are performed by SCIATRAN automatically employing the incorporated Mie code. SCIATRAN users can select different OPAC components in different altitude layers.

More detail on using OPAC is included in the revised manuscript (see lines 202-204 in the revised version).

Line 243: the same applies to OPAC aerosols, where optical properties can be specified.

Response: In the case of OPAC V4.0, the aerosol optical properties are specified using SSA, extinction coefficients and phase functions from the database.

Line 243 refers to OPAC V 4.0 We made it more clearly in the revised manuscript (see line 236 in the revised version).

Line 265: logarithms/exponentials of dimensioned quantities units are used. The formula should be modified so that no dimensioned quantity is used as an argument to ln or exp.

Response: The argument of exponential in Eq.1 is dimensionless because $\ln r - \ln r_v = \ln(r/r_v)$ and standard deviation is defined with respect to the dimensionless variable $\ln(r/r_v)$.

Line 286 Same remark. Moreover, the dimension of both sides should be the same.

Response: The dimension of both sides of Eq. 3 is the same. We note that N_0 is the number of aerosol particles in a vertical column of unit area, having dimension $1/\mu m^2$, V_0 is the total volume of particles in vertical column of unit area, having dimension $\mu m^3/\mu m^2$ (see Table 2 of manuscript), therefore the dimension of the right hand side of Eq. 3 is $1/\mu m^2$, i.e., the same as dimension of left-hand side.

Line 296: it is said that the user can define the shape of the aerosol number density vertical distribution. What is the default shape (i.e. if the users does not define it)?

Response: The default shape is a constant value within an aerosol layer.

We have added this information in the revised manuscript (see lines 287-288 in the revised version).

Paragraph 4.1.4 : why a "dust aerosol type" is mentioned, whereas, in this paragraph, other aerosol types are mentioned (OPAC, XBAER-OC, MODIS-DT), which are considered in other paragraphs ? This paragraph should focus on the Dubovik dust aerosol type, which is not described elsewhere.

Response: Section 4.1.4 describe Dubovik dust aerosol type, we have changed the title of this sub-section from ‘Dust aerosol type’ to ‘Dubovik dust aerosol type’ in the revised manuscript.

Line 389: for the "size bins" tracer: is it an aerosol with a defined size ? This aerosol type should be precised.

Response: Yes, in MERRA, each aerosol component is defined by a fixed size distribution. We have added this information in the revised manuscript (see lines 279-281 in the revised version).

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Line 406: mixing ratio: with respect to dry air?

Response: mass-mixing ratio is given for dry air.

Line 442: is soot accounted for by adding an extra aerosol type? Or by considering a layered sphere with both water (liquid or solid) and soot?

Response: Contribution of soot is accounted for by adding a specific aerosol type.

Line 490: in [Yang, 2013], there are 11 habits, not 9.

Response: This has been updated in the revised manuscript (see lines 471-475 in the revised version).

Line 497: It would be nice to have more details about the implementation, even if the full description is available in [Pohl 2020]

Response: The extinction cross-section, single scattering albedo, non-zero elements of the scattering matrix, effective radius, projected area, and volume of each habit at 189 dimensions were used from original Yang database. The expansion coefficients were calculated expanding the elements of the scattering matrix in the generalised spherical functions.

We have included additional details with respect to the implementation of Yang database in the revised manuscript (see lines 478-483 in the revised version).

Line 565 and 580: without going into the details of Malinka's articles, it would be nice to recall briefly the principle of stereological approach and the definition of chord length.

Response: A brief description of the main principle of stereological approach and the definition of chord length are included in the revised manuscript (see lines 545-553 in the revised version).

Lines 588 and after: some details would be given about the RPV and Kernel-based Ross-Li. Not a full description, but something basic which would avoid the need to look in the references.

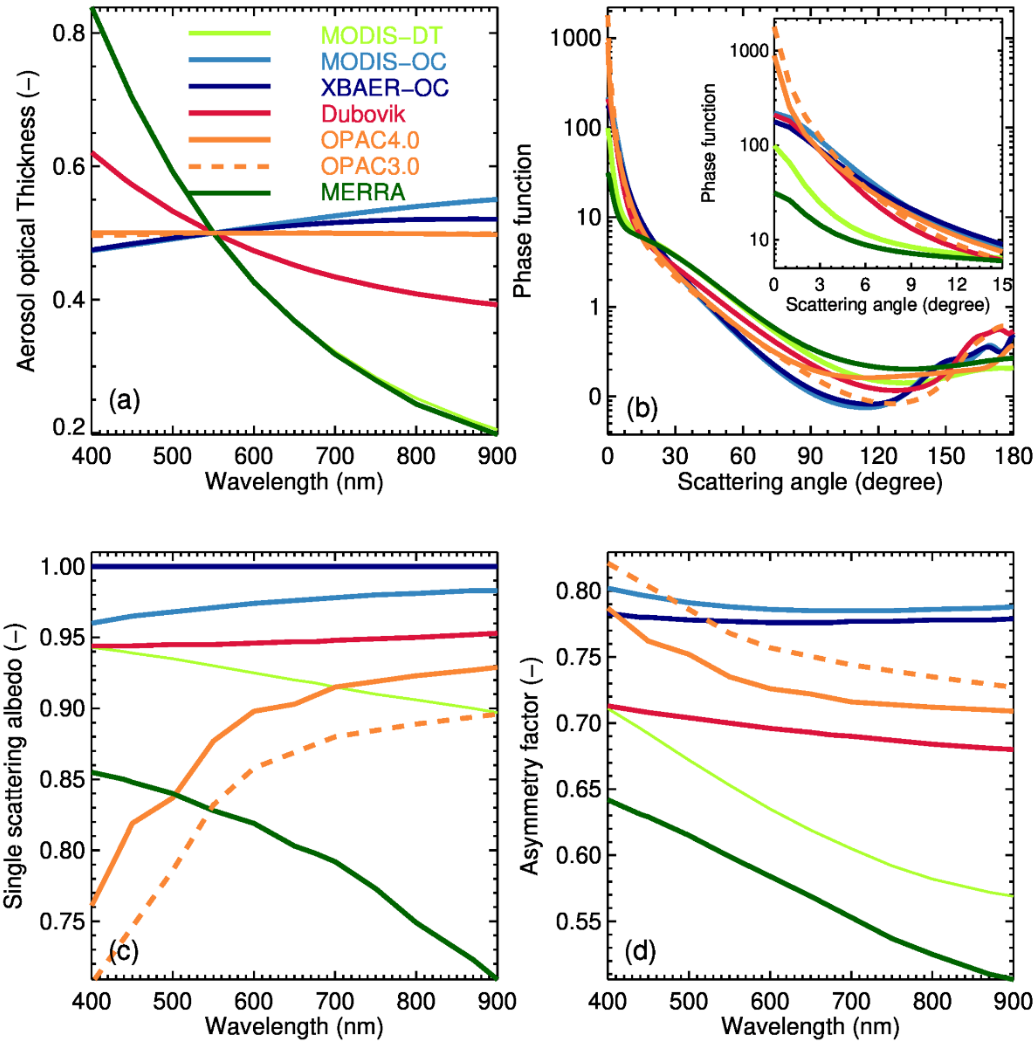
Response: A brief description of the above-mentioned models is given in Appendix B of the revised manuscript.

Line 775: "newly implemented in SCIATRAN aerosol types" => "aerosol types newly implemented in SCIATRAN".

Response: This has been corrected in the revised manuscript.

Figure 3b: it is difficult to see the difference between the forward peaks of the different aerosols, which are mentioned in lines 800-810. Perhaps adding another figure for the phase function, zooming on 0 degree scattering angle.

Response: A sub-panel inside Fig 3b is included to zoom-in the region from 0 to 15 degree scattering angle.

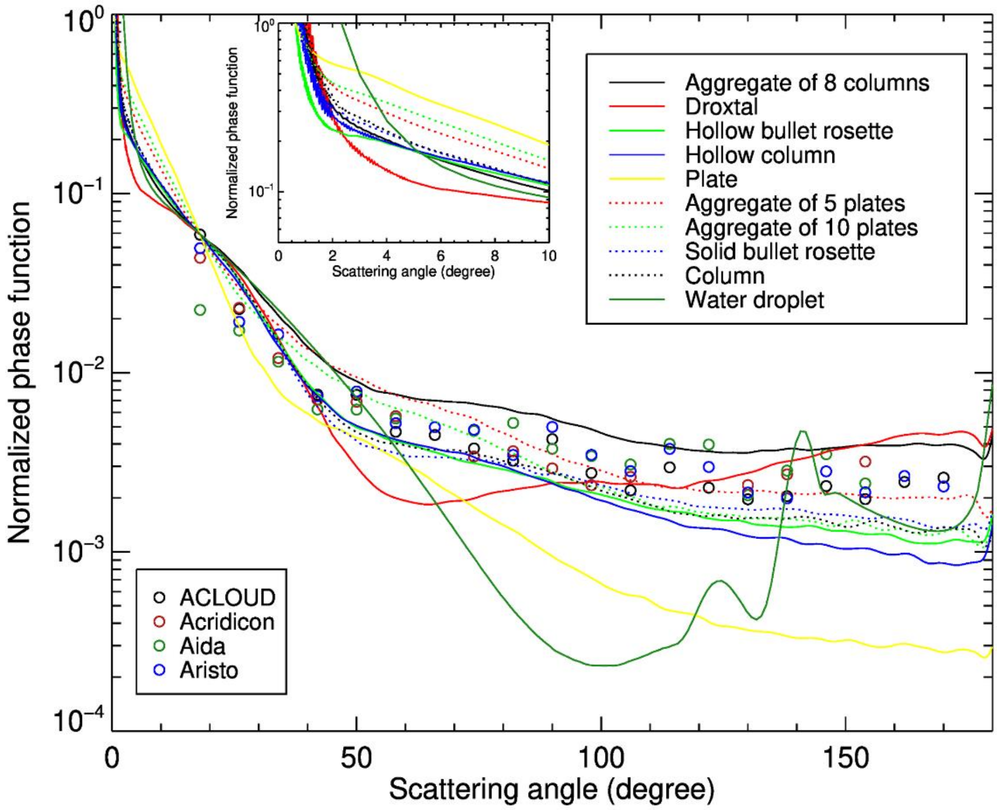


Caption of figure 3: "newly implemented in SCIATRAN aerosol types" => "aerosol types newly implemented in SCIATRAN".

Response: This has been corrected in the revised manuscript.

Figure 4: it would be nice to have another figure, zooming on 0 degrees, to better see the forward peak.

Response: A new figure is included in the revised manuscript.

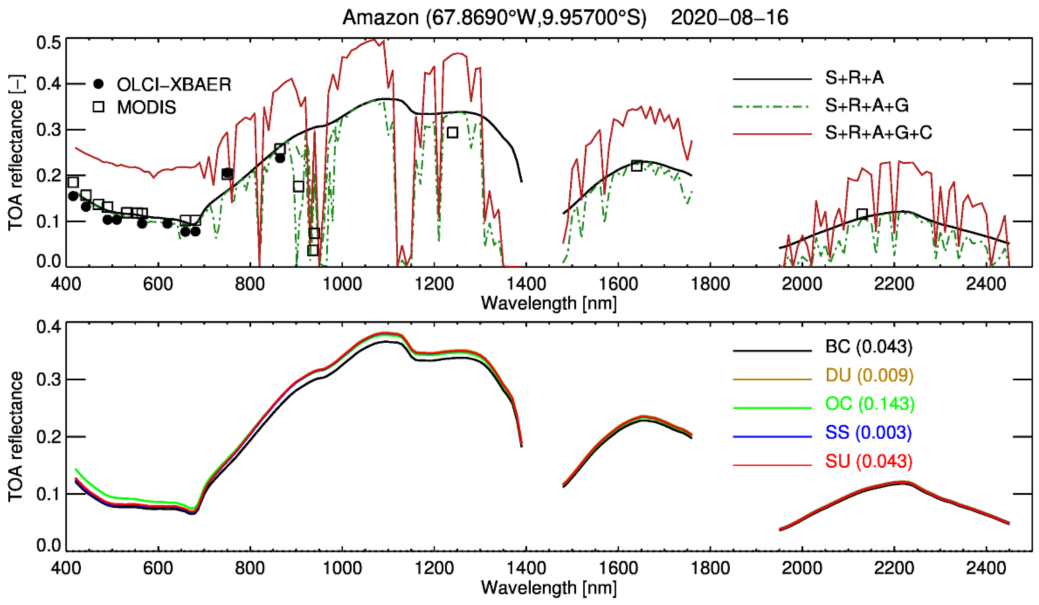


Line 888: for S+R+A, the agreement with MODIS is not so good above 900 nm , if we look at fig 5.

Response: The difference between the PROSAIL simulation and the MODIS observation can be explained mainly by the inaccuracy of PROSAIL for the selected scenario. Only LAI value is estimated from satellite observations while other input parameters of the PROSAIL model are based on previous publications, which might be unsuitable for the considered measurement conditions.

Line 904 and bottom of figure 5: It would be more clear to plot the total TOA reflectance and the contribution of each aerosol, instead of the difference.

Response: The figure has been updated. The TOA reflectance of each component, rather than the difference is shown in the revised version.

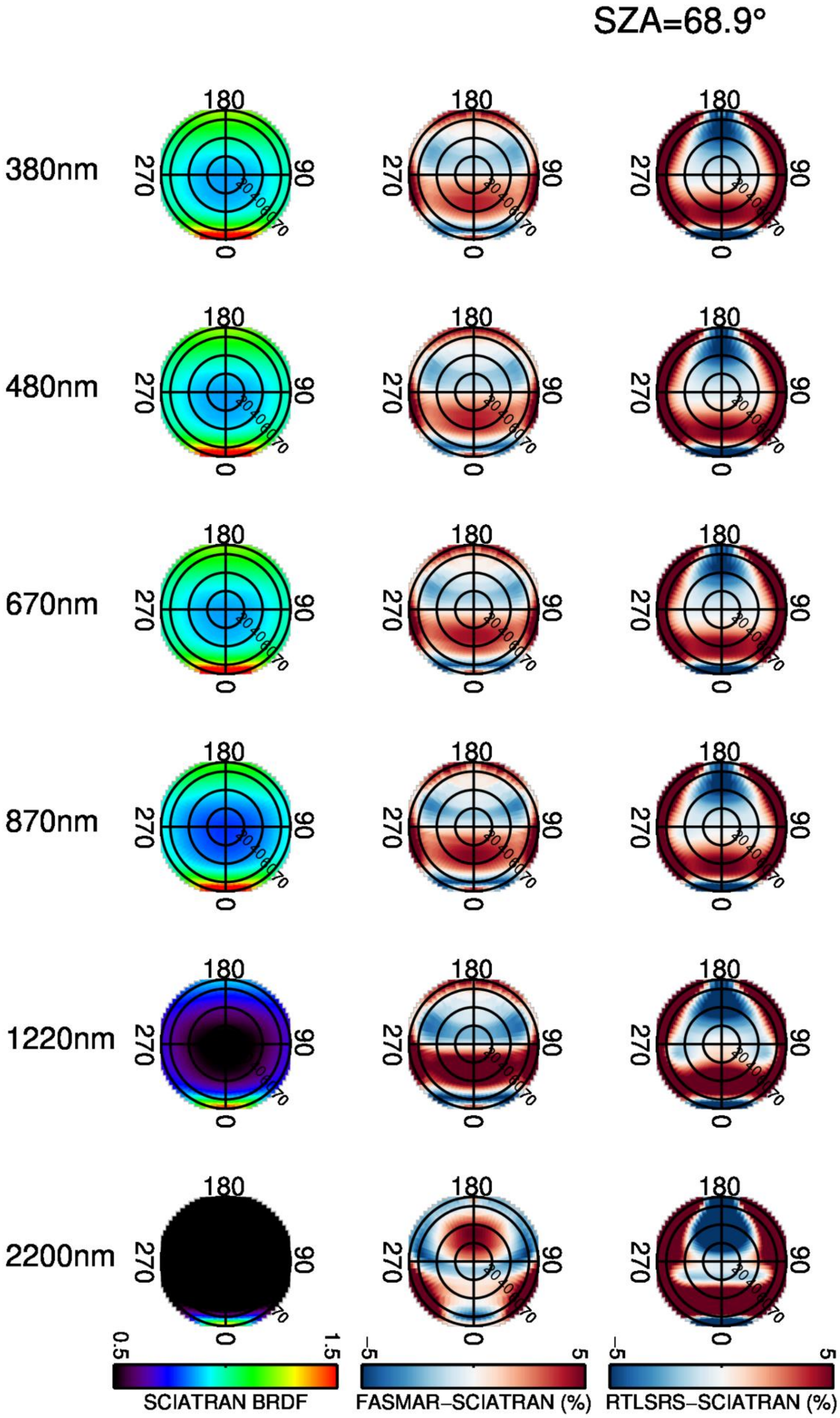


Line 927: could you give some examples of such satellite instruments?

Response: These instruments are MODIS, MERIS/OLCI, AATSR/SLSTR and so on. This information is included in the revised manuscript (see line 908 in the revised version).

Figure 6: it is not so easy to compare SCIATRAN BRDF to RTLSRS and FASMAR BRDF. Another figure, with the same kind of graphs, but with the difference SCIATRAN - RTLSRS and SCIATRAN - FASMAR would allow to see more clearly the differences.

Response: A new figure to show the difference is included in the revised manuscript.


SZA=68.9°
380nm
480nm
670nm
870nm
1220nm
2200nm
180
90
0
270
0.5
1.5
SCIATRAN BRDF
-5
5
FASMAR-SCIATRAN (%)
-5
5
RTLSRS-SCIATRAN (%)

Lines 958 -> 968. It is nice to see that SCIATRAN can well reproduce the measurements by choosing the parameters that minimize the residual. What would be interesting is to give the experimental values of snow layer optical thickness and (if available) mean chord and DOM absorption. The comparison of these experimental values with the parameters would be interesting.

Response: Additional information is included in section 4.2.2 and with a new table (Table 6). Meanwhile, we are preparing another paper for this topic, which will be submitted to GMD soon.

Lines 996 -> 995 Same remark: It would be interesting to give the experimental values of ice thickness, water depth and (if available) transport scattering coefficient.

Response: Additional information is included in section 4.2.2 and with a new table (Table 6). Meanwhile, we are preparing another paper for this topic, which will be submitted to GMD soon.

TECHNICAL CORRECTIONS

Line 311: typo: wavelegths => wavelengths

Response: Done

Line 855: responce => response

Response: Done

Line 924 show => snow

Response: Done

Line 993: "the optical" => "an optical"

Response: We believe the reviewer refers to Line 983 and this has been corrected in the revised manuscript.

Line 994: "the geometrical" => "a geometrical", "the top height" => "a top height"

Response: We believe the reviewer refers to Line 984 and this has been corrected in the revised manuscript.