Answer to Reviewer 2

The authors thank to the reviewer for the effort to review the manuscript and for its detailed comments.

Reviewer comments

The authors present a "simple, fast, and accurate" hyperspectral solar radiative transfer model for clear skies (SSolar-GOA v1.0). They evaluate the model against a state-of-the art radiative transfer model (libRadtran) and observations, showing an impressive accuracy and promising applicability in a multiple of different disciplines. ***Although, the overall analysis, focus, and results are, to an extent, appropriate for Geoscientific Model Development, as well as novel and important, I found the writing, organization, and presentation of results severely lacking. I would recommend thorough revising before further consideration***. I provide more detailed comments below, however I do think considerable revision is needed before a proper evaluation can be completed

PRIMARY COMMENTS

1. As stated throughout, I found the writing rather awkward, poor, or extremely confusing in several areas. This makes it challenging to follow the rationale, results, and discussion. Please consider a careful review of the writing with extra attention paid to sections/sentences that are awkwardly written.

2. The presentation of results focuses are merely visual or limited to percentual differences. A lot can be learnt from linear fits, and their r2's and RMSE's values. See specific comments for more context.

3. The model seems to do a great job, but the paper would be more interesting if the authors could explore limitations of the model as well, and move faster to results and discussions. Maybe add more discussion describing how the model could be improved, what areas are lacking, what type of simulations and scientific questions cannot be explored with this model, and how other areas could potentially benefit from this. I know the authors refer to other studies, but without really giving any concrete example in the paper. This is a real breakthrough and I can indicate a few:

Yang, P., Prikaziuk, E., Verhoef, W. and Van Der Tol, C.: SCOPE 2.0: a model to simulate vegetated land surface fluxes and satellite signals, Geosci. Model Dev, 14, 4697–4712, doi:10.5194/gmd-14-4697-2021, 2021.

Braghiere, R. K., Wang, Y., Doughty, R., Sousa, D., Magney, T., Widlowski, J.-L., Longo, M., Bloom, A. A., Worden, J., Gentine, P. and Frankenberg, C.: Accounting for canopy structure improves hyperspectral radiative transfer and sun-induced chlorophyll fluorescence representations in a new generation Earth System model, Remote Sens. Environ., 261, 112497, doi:10.1016/j.rse.2021.112497, 2021.

Response to general and primary comments by the authors. To do this we have numbered the paragraph

1. We have followed most of the reviewer recommendations in order to improve the manuscript. Regarding the writing, we try to improve it, but we also think that the editorial can improve it in the article as a whole. Certainly the writing is not as good as we wish. We are not English natives but the text was proofread by a professional English translator and in our opinion it follows the normal rules of English language and the sentences commonly used in our research field.

2. We have evaluated the statistical RMSE% and the parameters of the linear regression for the comparison in tables I and II. These values are also discussed in the analysis of results in the new version of the manuscript. We consider that figures of the fits do not report more significant information, hence they are not included since they greatly lengthen the manuscript. However, we show some of them here below.

3. We have changed the paragraph “Conclusions” for a new one called “Discussion and conclusions”, where we emphasize the limitations and advantages of the model, how the model could be improved or in which areas it can or cannot be applied as the reviewer recommends.

Abstract

The abstract is too long and contains some methodology. The abstract should concise and describe general relevance and main results. Line 12-18 could be removed. Starting the abstract with the general applicability of the study may attract interest. This section should be re-structured.

Response: The abstract has been shortened and restructured. However, the main characteristics of the physical methodology must be clearly explicit: it is the core of the model and defines the model with respect to other models that are based on the two flux methodology. As we mentioned in the text, the model tries to fill the gap between the detailed-complicated RT Codes and the most simple parameterized solar radiation models (mostly based on experimental data).

Line 10: are adapted? It looks like something is missing. It looks like it is a direct translation.
Response: sorry this is an error where “are” is “and”, but this sentence has been removed in the new manuscript version.

Line 14: “sufficient accuracy” – can you provide an r^2? A RMSE in percentage? Anything that exemplifies what that means.
Response: This statistical indicator has been added and evaluated in the new Tables I and II.

Line 28: Avoid wording like “obviously” in scientific writing.
Response: Yes, it was removed.

Introduction.
Line 32: Earth-atmosphere System
Response: done

Line 36- energy?
Response: replace by “solar energy”

Etc is a vague word and should probably be used minimally.
Line 45 – what is etc? be precise. Please define the spectral wavelengths associated with UV, visible, etc.
Response: “etc.” has been removed. The spectral ranges have been clarified and added as: *“(i.e., UV (~300-400 nm), visible (~400-700 nm), near-infrared (~700-1000 nm), entire solar range (~300-3000 nm))”*.

Line 55 – do not refer other studies in this way. Just write these between brackets.
Response: Done

Line 60 – etc.
Response: it has been removed.

Line 71 – 1-10 nm is low to medium? Don’t you mean medium to high?
Response: we consider “high” below 1 nm. Most of detailed RT models for atmospheric science applications works with a spectral resolution below 1 nm. See that in RT Theory most if the classical books start with gas molecular absorption, and hence with the concept of “line absorption” and its parameters, like position, intensity and half-width and hence the line-by-line models are recommended for many applications. Considering this type of RT Codes, to work with 1 nm is consider a wide interval where thousands of spectral lines are included, but it also depends on whether we are in the UV at 0.3 μm or in the far-infrared about 15

μm. On the other extreme are the RT models used by climate models, where solar range is taken with 1 or 6 intervals as maximum and hence the K-distribution is currently applied. In satellite remote sensing applications, the term “hyperspectral” is considered as a high spectral resolution but this is relative. Currently sensor satellite remote sensing applied to vegetation used less spectral resolution that those use for the atmospheric component determination. However, to say low, medium or high is “relative”, in general depends on the context you are working or speaking and it will depend on each specific area of work.

Line 79 – libRadtran reference?
Response: Done

Material and methodology.
This sections is way too long and could be substantially reduced, with some of the sections moved into a Supplementary material or appendix.
Response: The last paragraph has been removed and sent to section 4.2. To add supplementary material or appendix enlarged the article.

Line 139 – etc.
Response: removed.

Line 142 – Earth
Response: done.

Line 159 – the BLB law.
Response: done.

Line 160 – which component?
Response: Done, the sentence was modified as “only to direct component.

Line 161 – This gives rise? What does that mean?
Response: this sentence has been replaced by “This allows”.

Line 163 – etc. Paragraph 3.1?
Response: done.

Line 164 – there are two verbs in this sentence.
Response: yes, the verb “is” has been removed.

Line 165 – you already defined RTE before.
Response: yes, thank, we only put RTE.

Line 166 – to solve -> solving
Response: done.

Line 168 – specific problem involved? This is so general. Give examples
Response: yes, it is so general but it fits the phrase where it is included, we do not believe any further clarification, we refer to the books where the specific problems are solved.

Line 172 – ETR?!
Response: all “ETR” have been replaced by “RTE”.

Line 173 – for the diffuse component only.
Response. done, we also have removed the parenthesis after global component in this sentence.

Line 174 – Not only to the atmosphere, but adapted for canopies to:
Sellers, P. J.: Canopy reflectance, photosynthesis and transpiration., Int. J. Remote Sens., 6(8), 1335–1372, doi:10.1080/01431168508948283, 1985.
Response: yes, it is true, certainly the methods for solving the RTE can be used or applied to atmosphere and vegetation studies and the SSolar-GOA model may serve as input for vegetation transfer models at the canopy level, as SAIL, SCOPE and others, providing spectral solar irradiances at the top of the canopy. Bear in mind that our main area of research is the atmosphere but vegetation radiative transfer models are also familiar in our research group (see the reference Berjón et al. (2013)). Many thanks for these two recent references. We have tried to incorporate this information in the discussion section.

Line 179 – ETR?
Response: done.

Line 197 – BLB law.
Response: done.

Line 212 – period missing.
Response: done

Line 224 – Again, 1-10 nm is a very resolution.
Response: it has been discussed above.

Line 226 – what is this error?
Response: about 2-5%, this information has been added in the text.

Line 231 – Thank you for giving the link to the model. How can the direct component be higher than the global one for some wavelengths?
Response. as can be seen in Figure 1b and c, for normal input parameters as those of the figure but for SZA higher that 30 degrees, direct normal component is higher that global but not the horizontal component.

Line 233 – You already defined BLB.
Response: done.

Line 289 – Use the symbol of micrometers.
Response: done.

Line 321 – 1 DU instead of 1 Dobson.
Response: done.

Section 3.3. This list of items could be a Table.
Response: Yes, but it is an option and not relevant since there is not so much information.

Results.
Fig1. Add degrees to the numbers next to SZA. Write down Direct-horizontal instead of **dir-how**. Figures should be directly interpretable.
Response: done.

Line 444 – Before the comparison? What?
Response: We have replaced the sentence by “Before the comparison between both models”,

Fig 1 and 2 could be combined into one single figure, with the top row being fig 1 and bottom row fig 2. Ozone = 300 DU, not Dobson. Add units of all the other parameters too.
Response: to join Figure 1 and 2 is not convenient since they give different information. Figure 1 gives a general idea about the values of the three component and their variation with the SZA. Figure 2 is related or

equivalent to figures 4 and 5, giving direct normal, global and diffuse information about the comparison with libRadtran, therefore we think joining figure 1 and 2 is not convenient. Ozone unit as DU has been added. The water vapor is the only with units as already it appears (as cm) and the other are dimensionless.

Fig3 should include SZA= 6 deg as well. Be consistent.
Response: Figure 3 is not equivalent to figures 2, 4 and 5. This is the reason why we don't draw the corresponding 6° or 60°. This Figure 3 is shown to emphasize the different spectral resolution between the libRadtran and SSolar-GOA models as revealed by the absorption of water vapor bands, giving rise to the high differences observed as both positive and negative peaks.

Fig 4 is repetitive and could probably be moved into supplementary material.
Response: we consider that Figure 4 is not repetitive, it is consistent with Figure 2 and 5.

Line 533 - see libRadtran user Ì□s guide, 2015? Please reference appropriately.
Response: done. The reference is already given above.

Fig 4 and 5 could be combined into a single one too. Same thing about adding degrees next to the SZA numbers throughout.
Response: we have explained the consistence of figures 2, 4 and 5. Degrees have been added in all the figures and text.

Fig 6 – what are the different colors? Please use an include color scheme suitable for colorblind people.
Response: we have added the values of four SZAs as required by reviewer 1, and the symbol of degrees to SZAs.

Fig 7 – Please add the runs from libRadtran here for comparison too.
Response: this has been discussed above.

Line 586 – How do you know the agreement is "excellent"? Visually, it looks great, but could add some statistics into your evaluations? A linear fit with observed/simulated with libRadtran versus SSolar-GOA (r_2, RMSE, and slope) could tell us so much about model performance.
Response: done.

Fig 8 - Please add the runs from libRadtran here for comparison too.
Response: we have dedicated the first part of the article to this comparison with libRadtran. We think that the addition of the modelled data by libRadtran to the measured data is confuse for this figure. Our purpose here is validating the SSolar-GOA model con experimental data.

Fig 9 – This is not your work, could probably be moved into supplementary material. Please add the full citations in the figure, e.g., Kurucz, 1992.
Response: Yes, it is a possibility, but we prefer to present figure 9, since these differences between the values of the extraterrestrial irradiances are very important when analyzing the absolute and relative differences in the comparison between experimental and modeled solar radiation spectra. Although this is well known, the values of these differences must be remembered (as it is illustrated in the figure) when making the comparison between modelled and measured spectra. Citations have been added to the Figure as required.

Line 634 – add comma after 'To this'.
Response: done.

Fig 10 – show linear fit with r_2 and RMSE.
What is the purpose of Fig 11?

Response: We have added Tables I and II for the earlier figures 7 and 8; we consider that all information is collected in these tables. Figures 10 and 12 are not illustrated for comparison objective, but they want to emphasize the different capabilities of the ASD compared with other spectroradiometers: its largest spectral range from 400 to 2200 nm (thus, loosing information in the UV range) and is high time resolution, which can be of interest for other type of applications.
The purpose of figure 11 is to show that reliable AOD values are used as input in all modeled data in the comparison between modelled and measured solar spectra and that AOD is the main parameter in the comparison of solar irradiances under clear skies.

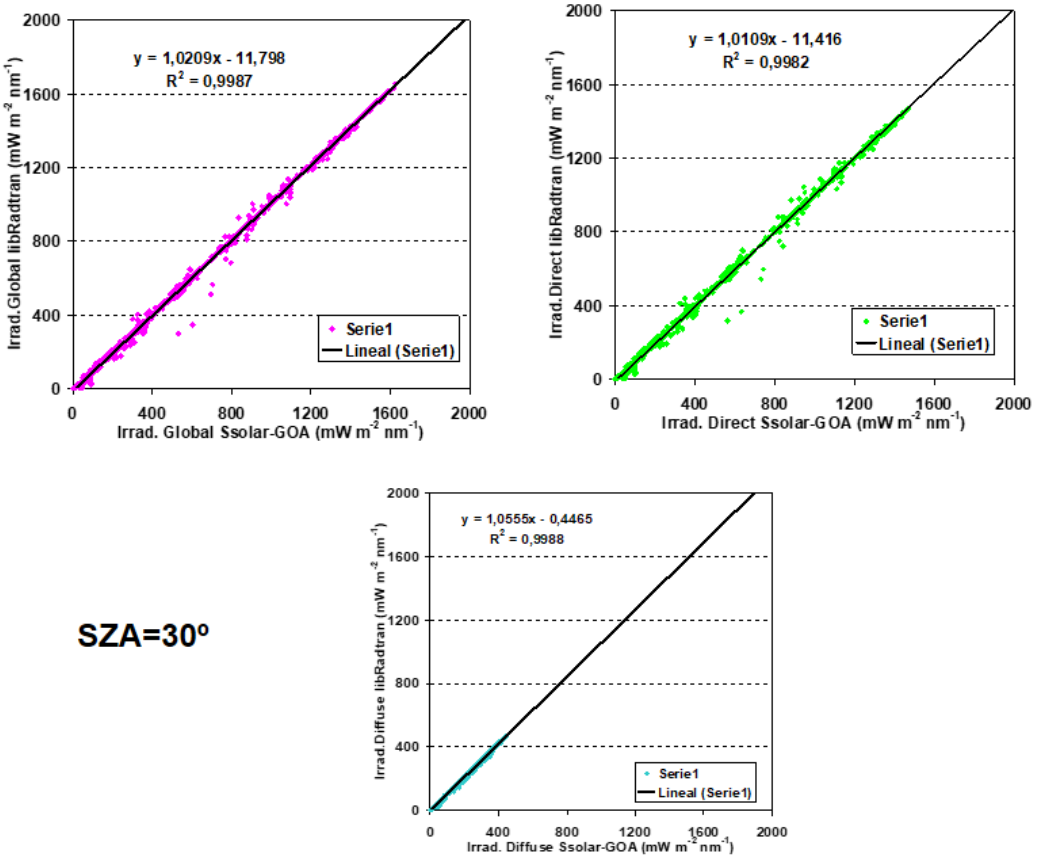
Fig 12 – show linear fit with r_2 and RMSE.
Response: it has been discussed above.

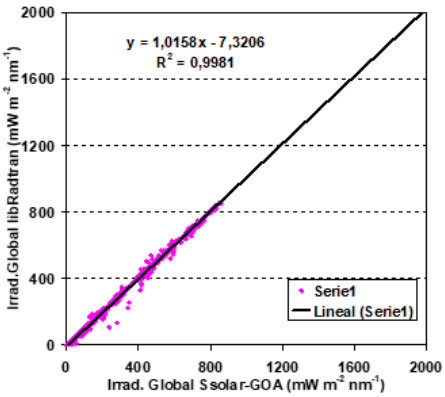
Conclusion.

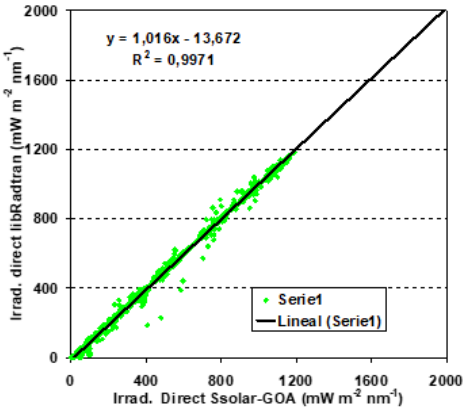
Line 708 – avoid huge and extensive.
Response: done.

Line 711 – avoid enormous.
Response: done.

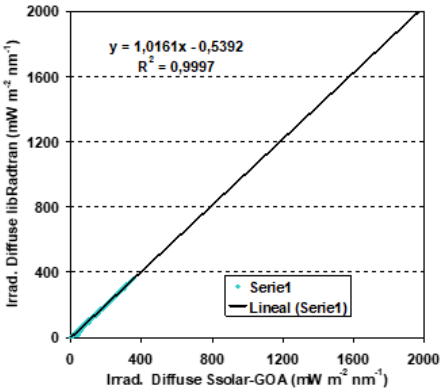
Figures of linear fits

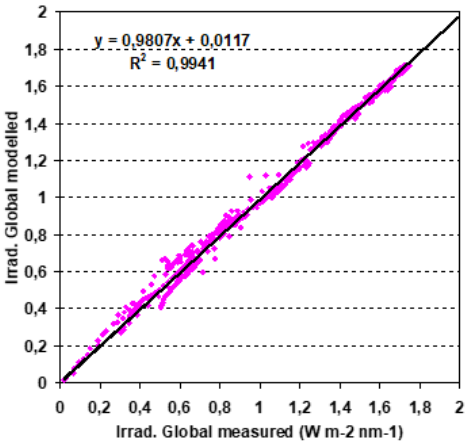


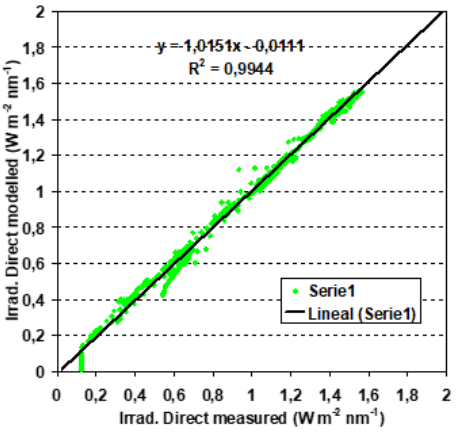

y = 1,0158x - 7,3206
R2 = 0,9981
Serie1
Lineal (Serie1)
Irrad.Global libRadtran (mW m-2 nm-1)
Irrad. Global Ssolar-GOA (mW m-2 nm-1)
0
400
800
1200
1600
2000


y = 1,016x - 13,672
R2 = 0,9971
Serie1
Lineal (Serie1)
Irrad. direct libRadtran (mW m-2 nm-1)
Irrad. Direct Ssolar-GOA (mW m-2 nm-1)
0
400
800
1200
1600
2000

SZA=60°


y = 1,0161x - 0,5392
R2 = 0,9997
Serie1
Lineal (Serie1)
Irrad. Diffuse libRadtran (mW m-2 nm-1)
Irrad. Diffuse Ssolar-GOA (mW m-2 nm-1)
0
400
800
1200
1600
2000





Day 16 July 2002,
Veleta Campaign