Dear Editor

Due to the harsh comments from reviewer 2 (first paragraph of the review) we have followed most of its recommendations in order to improve the manuscript, but the organization and presentation of results are difficult to change as a whole. We found these sentences (see black sentences paragraph below) quite contradictory and harsh, where the work is valued as important and novel, but the writing, organization and presentation of results are very deficient (severely lacking).

Most severe comments are focused on the writing of the article. We have tried to improve it, but we also think that the editorial can improve the text 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. Two of the authors have published more than 200 peer-review articles. We have changed the section of Conclusion by "Discussion and conclusion" where we emphasize the limitations and advantages of the model and its possible improvement as required by the reviewer. Minor grammatical errors or misunderstandings in the manuscript were also corrected, but regarding organization and presentation of results we cannot modify them substantially.

According to the reviewer2 the "presentation of results" are "severely lacking". To solve this problem we have followed its recommendations about the statistical evaluation of the results (shown in the different figures) applying linear regression and the RMSEs parameter as shown in Tables I and II. We have not added the figures of linear regression because we consider that they are not relevant (See Table I) and lengthen the article.

We kindly ask the editor to carefully read our responses to the reviewer 2.

Sincerely yours

Dra Victoria E. Cachorro

---------------------------------- Main Comments of the reviewer 2 ----------------------------

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

Answer to Reviewer 1

Answers to the reviewer CrVirac for the manuscript
"SSolar-GOA v1.0: a simple, fast, and accurate Spectral SOLAR radiative transfer model for clear skies" submitted to Geoscientific Model Development (GMD) by Victoria Eugenia Cachorro, Juan Carlos Antuña-Sánchez and Ángel Máximo de Frutos

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

General Comments

The paper presents the SSOLAR-GOA model, which is a spectral radiative transfer model for the solar radiation under clear skies. The model provides global, direct and diffuse irradiances at the surface. The model is rather simple, since it assumes the atmosphere is a single homogeneous (plane-parallel) layer – a mixed layer of molecules and aerosols. The paper describes all components of the model in a clear manner. In addition, the model code is well documented and easy to use with a nice graphical user interface. The SSOLAR-GOA irradiances are validated against those simulated with the radiative transfer package libRadtran as well as field measurements. The results of this comparison are thoroughly elucidated. The model generally shows a good agreement with libRadtran simulations and measurement data throughout the majority of the solar spectrum under presented clear-sky conditions.
However, my research focus is radiative transfer in the presence of clouds – therefore my principal concern lies in the general applicability of this clear-sky model. Clouds are the main atmospheric modulators of solar radiation and profoundly impact surface irradiance. The incorporation of cloudiness in radiation codes is well established and should be considered in the next stage of the SSOLAR-GOA model development.
Overall, the paper is well structured and written (although grammar should be improved at several places). I support it for publication in GMD after a few comments are addressed as outlined below.

Response: We answer to the main concern of the reviewer. The main aim of this work is to deliver a simple spectral solar radiation model under clear skies to a broad users community, not familiar with radiative transfer theory and specially to people in solar energy applications or educational frameworks, thus the applicability of the model is well defined. Spectral solar radiation models based on physical fundamental are scarce in most of these communities, being the majority of models obtained by parameterizations or expressions based on experimental data. The objective of this paper is to fill the gap between the Radiative Transfer Codes and those more simple solar models, working as an intermediate stage between them. The same reviewer emphasizes the simplicity of the model, "a single layer and not include clouds". The model emphasizes the Ambarsumian´s methodology of "addition of layers" to get an effective layer where the transmittance is given by a very easy expression. The simplicity of the expression against the two fluxes methods existing in the bibliography is a merit to mention, together with the fact that this methodology is less known comparatively to the different two flux methods.

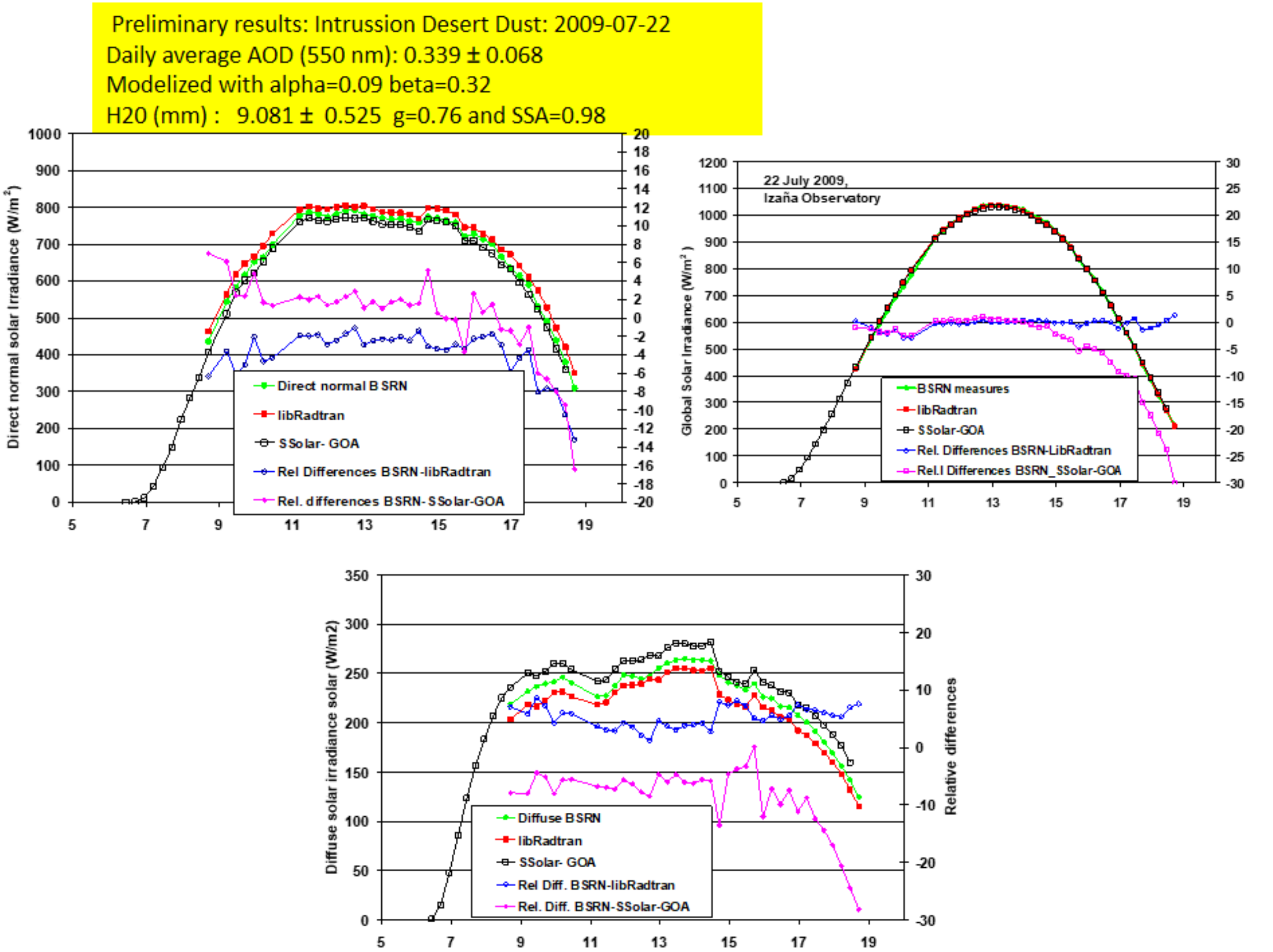
As recommended, our purpose in future works is to include a plane-parallel cloud layer giving an "effective cloud-layer" which can produce the same surface irradiance that multiple layers for cloudy cases. Also to compare the Ambarsumian method with other two fluxes methods, well known in the bibliography but with a most complicated expressions. First results indicate a different behavior in the range 350-450 nm between them, and further research should be carried out

Specific Comments:

Answer to point 1. This point was discussed above. We mentioned that future versions of the SSolar-GOA radiation model can include a cloud layer, but the transformation of the first version of the model, proposed in this paper, in a multiple layer model distorts the main objective of this work. As we mentioned, potential uses of the SSOLAR-GOA model are suitable for educational and solar energy applications, which do not need really the inclusion of cloud effect. We thanks the reviewer about the recommendation on the application of the method by Callahan et al. (1994) in future versions of the model. We agree this could be the physical bases if a cloud-layer is included in our model.

Answer to point 2. We agree with the reviewer, but the differences between our model and libRadtran model are not only due to vertical structure and multiple layers. The way to obtain the diffuse components of the two models (libRadtran and SSolar-GOA) is completely different and the limitations are already explained in the text of the manuscript.

In this context we have applied our model under strong aerosol conditions: a desert dust intrusion in the Canary Islands. The predicted by SSsolar-GOA and libRadtran and measured surface irradiances are shown in the next Figure (in this case with integrated values). As can be seen for global and direct irradiance components the comparison is very good: relative error below 5% despite considering constant values for alpha and beta along the day. The variations of these parameters were weak and the estimated irradiances match the experimental values. However, we are working about this subject to improve these results.



Answer to point 3. Corrected. We have updated the reference based on your suggestions.

Answer to point 4. Corrected the typo about Rayleigh optical depth of line 254.

Answer to point 5. The other two files of extraterrestrial irradiance have been added to Zenodo and they are available for calculations in SSolar-GOA model. Also as recommended one file of direct normal and global irradiances have added to ZENODO to enable reproducibility.

Answer to point 6. Thanks for the suggestion, this will be take into account in the future version of the model when added clouds. Partially cloudy cases are difficult to simulate by 1D models, but we are going to investigate about this topic for further versions of the model.

Answer to point 7. All the units have been corrected throughout the manuscript according GMD policy units.
Answer to point 8. Four labels about the SZA values have been added to Figure 6 as required.

Answer to points 9-14, about Technical corrections: typing and language errors.

Based on the reviewer's good suggestions, the minor grammar corrections have been done, as RTE for ETR, those for the uniformity of libRadtran and SSolar-GOA names, etc..

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.

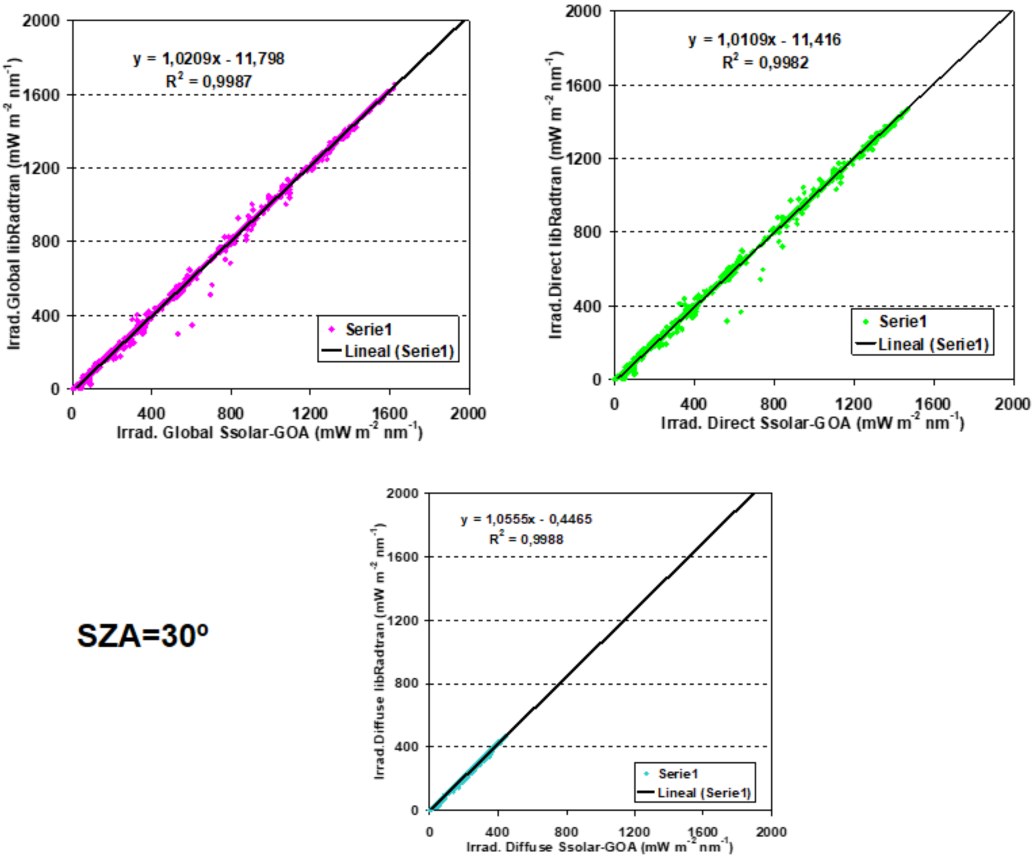
Fig 12 – show linear fit with r2 and RMSE.
Response: it has been discussed above.

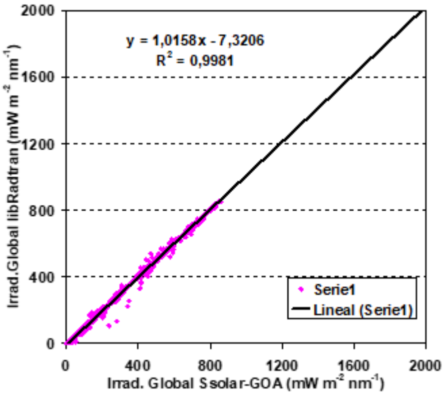
Conclusion.

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

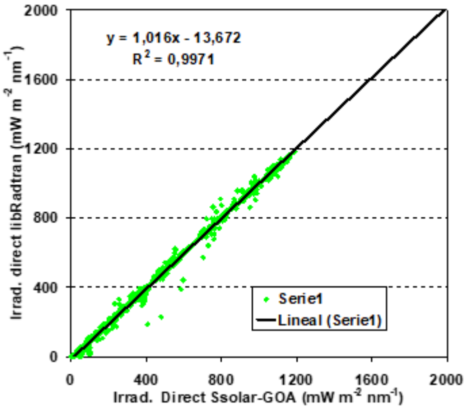
Line 711 – avoid enormous.
Response: done.

Figures of linear fits



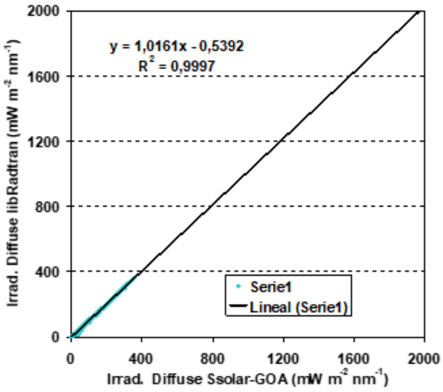


y = 1,0158x - 7,3206
R² = 0,9981
Serie1
Lineal (Serie1)
Irrad.Global libRadtran (mW m-2 nm-1)
Irrad. Global Ssolar-GOA (mW m-2 nm-1)
0
400
800
1200
1600
2000

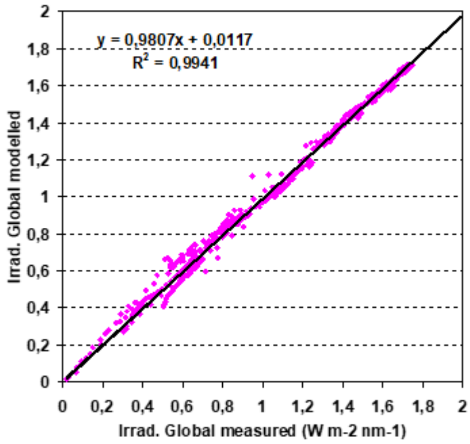


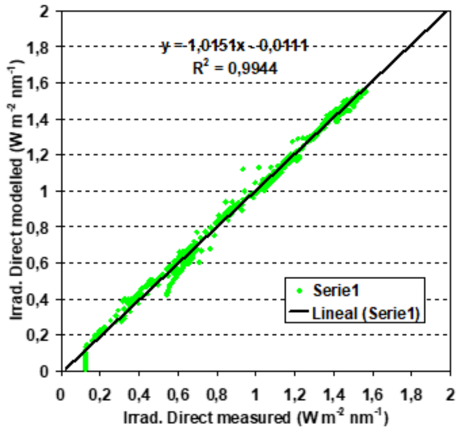
y = 1,016x - 13,672
R² = 0,9971
Serie1
Lineal (Serie1)
Irrad. direct libRadtran (mW m-2 nm-1)
Irrad. Direct Ssolar-GOA (mW m-2 nm-1)
0
400
800
1200
1600
2000

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