Nina Črnivec's Review of the paper:

"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

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.

Specific comments

1) You are assuming the model atmosphere is a single homogeneous layer of molecules and aerosols. This looks too simplistic to me and it imposes limitations on the range of model applications. Clouds are ubiquitous in the atmosphere and solar irradiance at the ground is highly affected by clouds (e.g., Wapler and Mayer, 2008; Wissmeier et al., 2013; Jakub and Mayer, 2015; Clack, 2017; Črnivec and Mayer, 2019). Moreover, broken cloud fields can even enhance the global (i.e., direct + diffuse) surface irradiance compared to that on a clear-sky day. I suggest that you incorporate cloudiness at least within your single-layer geometry (or even in a vertical 1-D geometry and thus additionally include vertical layering of the atmosphere).

Keep in mind that many studies demonstrated that further cloud characteristics such as cloud vertical overlap and cloud horizontal inhomogeneity strongly impact surface irradiance, whereby the first parametrizations of these effects were developed a long time ago (e.g. Cahalan et al., 1994; Shonk and Hogan, 2008). Some of them – like the methodology of Cahalan et al. (1994) to account for internal cloud inhomogeneity – are even extremely simple yet they offer a substantial improvement (perhaps interesting for your future model development).

2) Part of the inaccuracy of your model is stemming from the fact that you don't account for vertical variation of the atmosphere, which handicaps primarily the accurate computation of diffuse radiation (as you also indicate in Section 4). Furthermore, although three-dimensional (3-D) radiative transfer effects are mainly related to clouds, there are regions of increased horizontal variations of aerosol optical properties (e.g., in the vicinity of aerosol sources) or atmospheric gases, where your simple algorithm would fail even in clear skies – please point out these limitations.

3) Line 189: libRadtran user's guide, 2015: You should rather mention the latest version issued in 2020. Also in Line 534 as well as in the References – the url for the document provided within the References (http://www.libradtran.org/doc/libRadtran.pdf) already points to the version from 2020.

4) Line 254: The optical thickness related to Rayleigh scattering by atmospheric molecules should be denoted as τ_R and not τ_a, since the latter already denotes aerosol optical thickness.

5) In Line 435 you state that you have selected three different extraterrestrial work files in your model. You also show results using these various data. Can you provide the extraterrestrial irradiance files based on Wehrli (1985) and Gueymard (2004) in the model data folder? In the current Zenodo repository I can only find data from Kurucz (1992).

6) Section 4: You demonstrate that your model generally shows a good agreement with libRadtran simulations and measured data especially for direct irradiance (thanks to the classic Beer-Lambert-Bouguer law), whereas diffuse component exhibits a somewhat larger bias. While this might not be a big issue under clear skies where the diffuse surface irradiance is relatively low and has only a minor contribution to the global irradiance, the situation could change considerably in the presence of (partial) cloudiness. The latter would block a significant amount of direct radiation (reducing direct radiation reaching the surface) and simultaneously generate an increased component of diffuse surface radiation. This would act to increase the bias of global irradiance – an issue to bear in mind while extending your model to incorporate cloud conditions (suggesting that a more comprehensive parameterization of scattering might be needed together with the multi-layering of the atmosphere).

7) The way you currently write units for spectral irradiance in the entire manuscript (within the text as well as on figures): W/m^2 nm and W/m^2 µm is not physically correct (the correct form would be for example $W/m^2/nm$). However, according to GMD policy units must be written exponentially: $W\ m^{-2}\ nm^{-1}$ (see https://www.geoscientific-model-development.net/submission.html).
Please consider this also when writing units for other physical quantities.

8) Figure 6: Labels should be added for at least some of the lines.

9) Section Code and Data availability: Please provide also the surface irradiance data from field measurements (presented in Section 4.2) in a Zenodo repository (or other reliable repository) to enable scientific reproducibility. See paragraph Data Sets at:
https://www.geoscientific-model-development.net/submission.html

Technical corrections: typing and language errors

10) Ensure proper and consistent naming of libRadtran throughout the manuscript:
Lines 21, 23, 201, 203, 212 and 494: 'LibRadtran' should be 'libRadtran'.
Lines 500 and 759: 'Libradtran' should be 'libRadtran'.
I am not sure how to properly start a sentence with 'libRadtran', but I encounter both uncapitalized and capitalized versions in your manuscript (see Lines 185, 190 and 527). I would suggest you start sentences as follows: 'The libRadtran package...' or similarly.

11) Ensure proper and consistent naming of the SSolar-GOA model throughout the manuscript:
Lines 356 and 759: 'SSolar_GOA' should be 'SSolar-GOA'.
I also encountered 'SSolar-model' (Line 541) and 'SSolar model' ...

12) Some abbreviations are introduced multiple times. For example:
Line 165: Use simply the abbreviation RTE, since you have already defined it in Line 159: Radiative Transfer Equation (RTE).
Line 233: Use simply the abbreviated form ‘the BLB law’, since you have already defined the Beer-Lambert-Bouguer (BLB) in Line 159. Furthermore, the expression is misspelled in Line 734, since it contains ‘Bouger’ instead of ‘Bouguer’.

13) I noticed several very long sentences, which should be split into shorter sentences, for example:
Line 699: ‘Certainly, the spectrum at SZA=82.59 (m=7.3) represents an extreme situation with very low spectral irradiance values, which may be of interest for some applications, such as the determination of the amount of absorbing gas, but of little interest as a solar energy resource at middle latitudes, but not negligible in very low latitudes since there are a larger number of hours with this insolation.’

14) Some other language corrections (although I noticed additional grammar mistakes in multiple sentences, so please check grammar once more):
Line 164: ‘… is to separate...’ should be ‘… to separate...’.
Lines 172 and 179: ‘ETR’ should be ‘RTE’.
Line 209: ‘determine’ should be ‘determines’.
Lines 212 and 574: Dot (full stop) should be added at the end of the sentence.
Line 220: ‘one-dimension’ should be ‘one-dimensional’.
Line 448: ‘… their features on wavelength...’ does not sound fine to me.
Line 501: ‘consider’ should be ‘considers’.
Line 521: ‘increases’ should be ‘increase’.
Line 552: ‘were’ should be ‘was’.
Line 565: An additional parenthesis is missing after (2008).
Line 567: ‘provided’ should be ‘provide’.
Line 593: ‘thermal stabilized’ should be ‘thermally stabilized’.