

We would like to thank anonymous referee #2 for his comments that helped in improving the quality of our paper. The changes proposed by the referee are marked in the revised version of our manuscript with a blue color.

Major or specific comments:

1) “It would be very useful if you could draw a major conclusion as to which variable out of CFC, COT, and AOD were most important to the RegCM4-CM SAF SSR deviations over the whole of Europe and on an annual basis. This should be included in the paper and in the abstract.”

Answer: We address this issue in the revised version of our manuscript by adding a few lines in the abstract, in Section 3.6 and in the Conclusions section.

2) “Overall the data used in the analyses are presented clearly in section 2, but two of the subsections could be written more concisely dealing with the equations of Rel and Rei in section 2.1 and the CM SAF satellite data in 2.2. Please see the minor comments below for more details.”

Answer: Please find answers below (minor comments).

3) “Regarding the datasets used in the study, I recommend making a table to show all the variables and its source from the datasets used and their corresponding periods and original resolutions. The reader can simply refer to this table and see at once all the variables and datasets used for the analysis. Please see the minor comments for more details.”

Answer: We inserted a new table in the revised version of the manuscript (Table 1) with the parameters being analyzed in this work, their sources, the original resolution at which the data were acquired and the corresponding time periods.

4) “Detailed information was given on the biases found in the variables from the literature including the cloud property variables from CM SAF satellite but none on the other data (AOD, ASY, and SSA, ALB, and WV). Please add this in your section 2.3 Other data.”

Answer: We address this issue in the revised version of our manuscript by adding a short paragraph in the end of Section 2.3.

5) “As completed for the cloud fractional cover and the cloud optical thickness, additional comments should be made dealing with the spatial patterns seen in the cloud effective radius, aerosol optical properties, and other parameters (WV and ALB) compared to that of the SSR of RegCM. From a qualitative perspective, do these parameters explain the SSR patterns seen in Figure 1? Such comments should be made respectively at the end of their sections, i.e. sections 3.3.2, 3.4, and 3.5.”

Answer: We addressed this issue by adding a few lines in the end of Section 3.3.2 and 3.4. However, we would like to comment here that a direct connection of the observed SSR bias patterns with atmospheric parameters is not a straightforward procedure. An effort to qualitatively assess the RegCM4-CM SAF differences is mostly reasonable in the case of CFC, COT and AOD, since, these are the main determinants of surface solar radiation. On the other hand, in some cases (e.g. WV and ALB) the radiative effect of the examined parameters is either negligible or the bias they cause in solar radiation is monotonous (overestimation or underestimation for the whole region). In these cases it is obvious that we cannot reach safe conclusions (e.g. Section 3.5) and this was the reason why we decided to introduce the quantitative approach with the use of a radiative transfer model in this paper.

6) “The conclusion section seems to be a repeat of the results. If you do this, I recommend to make a summary of the results by writing these paragraphs more concisely. Also, a few comments as a separate paragraph should be written on comparing and/or contrasting these SSR results to the ones in the references you cited in the Introduction, i.e. Jaeger et al. (2008) and Kothe et al. (2011). The new title of this section should then reflect these changes and called the Summary and Conclusions section.

Answer: We followed the referee’s suggestion and shortened the conclusions section by more than 30%. Our conclusions are now presented in a more condensed and precise way. The studies mentioned by the referee are focusing on the net surface solar radiation where albedo plays a major role. Therefore, we selected not to mention these studies in the conclusion section.

Minor comments:

1) “Regarding section 2.1 on description of the model, where it is mentioned that the emissions are monthly historical, are they also time independent or not changing in time? If so, this would affect your results of simulated SSR. Please account for this in your conclusions.”

Answer: It is mentioned in the revised version of the manuscript that the emissions of the anthropogenic aerosols are based on monthly, timed-dependent, historical emissions from CMIP5. There is only a marginal change in the emissions that RegCM4 takes into account for the years 2000-2009 and the sub-periods 2000-2005 (MFG) and 2006-2009 (MSG) that we examine in this paper. Therefore our results would not be affected by the use of changing emissions.

2) “Lines 170-173: You mention the influence of CFC, Re, and cloud water path (CWP), but is there any particular reason you analysed the cloud optical thickness (COT) instead of the CWP or not analyzing both?”

Answer: COT along with CFC is one of the basic optical properties describing clouds and there are numerous studies in the literature using this parameter. So, COT

is considered an ideal parameter to describe the vertical development of clouds. Since we use COT and Re, the use of CWP would be meaningless, as these three parameters are connected with the following relationship: $CWP = \frac{2}{3} \rho Re COT$ (where ρ is the density of water).

3) “The equations that follow line 180 through line 194 can be all taken out and referred to from the studies of Giorgi et al. (2012), Slingo (1989), and Briegleg et al. (1992) if the reader is interested.”

Answer: Since our main target is this paper to serve as a textbook study for the evaluation of the ability of climate models to reproduce the SSR levels, we would prefer to keep these equations in the manuscript. This paper could serve as a bridge between the modelling and satellite community. Hence, we believe that details about the calculations done by the model and details about the satellite retrievals would be very helpful for members from both the communities to fully understand this research.

4) “Lines 223-229: This paragraph should be taken out and used instead in the introduction as you started in lines 82-85. Add this paragraph i.e, lines 223-229 to lines 82-85. As stated in the major revisions above, I recommend making a table at this point showing all the variables used, their data sources, periods, and original resolutions. It should also be made clear here in the text of this paragraph or somewhere in the introduction what period you will use for your main investigation. Following this in the introduction, you should also state here why you chose these data, such as its used as input for the radiative transfer model which is also used in the CM SAF SSR estimation as you pointed out in lines 377-380. It would be clearer to the reader if you pointed this out sooner as in the introduction..”

Answer: We addressed all these issues in the revised manuscript following the referee’s suggestions.

5) “Lines 251-298: The descriptions of the MagicSol-Heliosat algorithm and the MSG satellites should be written more concisely or condensed.”

Answer: The same answer as in minor comment 3.

6) “Lines 317-320: Is this homogeneity considered for Europe or globally?”

Answer: It is for Europe, we clarify this in the revised version of the paper.

7) “Lines 344-347: Does this bias refer to a global bias?”

Answer: It refers to SEVIRI’s disk; we also clarify this in the revised version of the paper.

8) “It is interesting that the results in Figure 10 for eastern Europe show that AOD contributes to the SSR positively for all months of the year, but why this is not reflected in the negative change in SSR in eastern Europe in Figure 1?”

Answer: We thank the reviewer for giving us the opportunity to clarify this. One should keep in mind that Figures 1 and 10 refer to % biases. For Eastern Europe the qualitative method predicts perfectly the relative seasonal variability of SSR bias, however, the surface radiation levels in winter and autumn are low, $\sim 38 \text{ W/m}^2$ and $\sim 85 \text{ W/m}^2$, respectively (among the sub-regions appearing in Figure 10 Eastern Europe exhibits the lowest SSR levels). This means that a 10% bias would be $\sim 4 \text{ W/m}^2$ and $\sim 8 \text{ W/m}^2$, which is below the combined CM SAF and radiative transfer model uncertainty. So, in this case one should not be very strict with the method and focus on the relative month by month seasonal variability of SSR bias.

Technical Comments:

1) “Line 8: Change the sentence to: “The SSR bias. . .”

Answer: Corrected in the revised version of the manuscript.

2) “The fonts of the figures in the main text of the paper should still be addressed as the fonts are still hard to read at that size.”

Answer: We will collaborate closely with the production team of the journal so as to make sure that the size of the figures and the size of the fonts will be optimal for reading.

3) “All figures: Larger fonts should be used for all parts of the figure. The same corrections should be made for all remaining figures.”

Answer: We will collaborate closely with the production team of the journal so as to make sure that the size of the figures and the size of the fonts will be optimal for reading.

4) “A black font or one that would be clearer to read should be used in figures 1,4, and 7. This refers to the text of different seasons on the upper left-hand corner of each panel in the map.

Answer: Unfortunately, when using black fonts this part of the maps appears very blurred. Prior to the submission of the paper we did several efforts with various colors and we concluded that white fonts with a black border were the optimal solution. However, once again we assure the referee that we will collaborate closely with the production team of the journal so as to make sure that the size of the figures and the size of the fonts will be optimal for reading.