

Interactive comment on “Long-term variability of solar irradiance and its implications for photovoltaic power in West Africa” by Ina Neher et al.

Ina Neher et al.

ina@neher-fischer.de

Received and published: 14 July 2020

The authors would like to thank the reviewer for comments and suggestions to improve the submitted manuscript. Below, all revision points are addressed and resulting text edits are included in the following way:

- *Reviewer's points are repeated cursive.*
- Answers to the reviewer's points are given.
- "New text included to the manuscript is given in quotation marks."

C1

Lines 22-23: you state climatological conditions governing a great area, you may support it with relevant bibliography?

We revised the text accordingly:

"West Africa receives high amounts of global horizontal irradiance (GHI) (Solargis 2019). With the descending branch of the Hadley Cell the Sahara and the Sahel zone are overall dry with little cloudiness leading to high sunshine duration (Kothe 2017)."

Lines 64-71: Apart from the study's area topography, from which I suggest to begin with, which provides the valuable information of mountain regions essential for cloud formation, you provide climatological conditions of study area especially surface albedo, mean cloud albedo, aerosol optical depth. You provide this information by figure 1 and there you explain briefly how these values are computed. Please, describe here how those values and fig 1 produced giving information in the manuscript about the data used.

We changed the order in Figure 1 to a) topography, b) cloud albedo, c) surface albedo and d) aerosol optical depth and included the source of the data in the text, as it now reads:

"West Africa is in general rather flat with highest elevations typically below 1000 m (Figure 1 a, Global Land One-km Base Elevation Project (GLOBE) database (Hastings 1999)). Some exceptions are the Mount Cameroon on the south-east of the study area along the border of Nigeria and Cameroon, Fouta Djallon and the Guinea Highlands in Guinea, Jos Plateau in the center of Nigeria and the Aïr Mountains in northern Niger. Here, but locally also for lower mountain ranges, orographically enhanced cloudiness might occur. The enhanced cloudiness associated to the moist tropical region is clearly visible in the mean cloud albedo used as input for the SARA-2.1 data retrieval between 1983 and 2017 (see Figure 1 b, from the SARHA-2.1 data set described later). Clouds have the major influence on the irradiance analyzed in this study. The West African climate zones relate to the albedo climatology (used for the SARA-2.1 data retrieval), with a higher albedo of up to 0.35 in the desert region in the north and

C2

a lower albedo of down to 0.1 in the forest region in the south (see Figure 1 c, Surface and Atmospheric Radiation Budget (SARB) data from Clouds and the Earth's Radiant Energy System (CERES)). Frequent dust outbreaks occur over the total region (Cowie 2014). Thereby, climatological highest aerosol optical depth (AOD) of up to 0.35 can be found in northern Mali (see Figure 1 d, from the European Center for Medium Range Weather Forecast, Monitoring Atmospheric Composition and Climate (MACC) and used for the SARA-2.1 data retrieval). "

Besides clouds, aerosols can have a significant impact on the analyzed irradiance. We added a sentence at the end of the paragraph:

"Besides clouds, aerosols can have a high impact on the irradiance and therewith on solar power (Neher 2019)."

Line 118: "for monthly mean temperature" maybe you mean daily mean temperature as you mention at line 124

Yes, you are right. We changed this in the revised manuscript.

Line 155: GTI and not GHI?

We left out this part of the sentence, as it might be confusing at this point which data is used later. However, we explain later, which data is used for the calculations.

Lines 159-160: maybe: the parameter b The slope α ?

Yes, we interchanged the parameters and changed the sentence, as it now reads:

"The parameter b indicates the impact of the inverter, as it needs a certain amount of power to work. The slope a indicates the efficiency, including the conversion of W/m^2 to kWh/kWp ."

Lines 212-213: the percentages inside parenthesis are reductions of RMSE? Are the

C3

right values because it doesn't make sense for example for Afougou compared to the values given in fig. 3

The values inside the parenthesis are reductions of RMSE. The RMSE given in Fig. 3 is reduced by these values, if only the situations with $AOD < 0.05$ are used.

Line 285: "... being significant" please rephrase that sentence and give additional information of how you assess the statistical significance of the linear trends?

How the statistical significance is assessed is given in lines 234-236 (revised manuscript: 243-245):

"The significance of the trend is checked by calculating the 95% confidence interval. The trends are significantly positive (negative) if the upper and lower value of the 95% confidence interval are positive (negative)."

However, we included a short definition of significance here again:

"However, the absolute values of the trend reach around $\pm 5 W/m^2/decade$ and being significant (based on the 95% confidence interval)."

Figure 8 caption: Trends of monthly mean anomalies were calculated and provided on the plots, if they were found to be statistically significant, please provide information about how you assess the statistical significance.

Due to the comment of another referee we changed the figure (Figure 9 in revised manuscript). Now only statistically significant cases are shown for the trend. We included the definition of significance again in the caption of the figure:

"Figure 9. Linear trend for global irradiance of the annual mean (a), as well as the dry (b) and the wet season (c), each for all significant cases (based on the 95% confidence interval). Ouagadougou, Burkina Faso and Dakar, Senegal are additionally visualized here, as values at these locations are compared within this section."

Figure 10 caption: The central line of those box plots provides mean value or median?

C4

Please explain and if is the median perhaps you should provide on this figure the median of the explicitly calculated PV yields for the three sites.

The central line of the box plots provides the median of the regional distribution within each latitude. The PV yield, however, is given as the temporal mean. Therefore, we also provided the temporal mean at the single locations, as these do not have a regional distribution. Furthermore, we included a sentence on what is shown in the figure, just before the figure:

"Figure 10 (Figure 11 in revised manuscript) shows the variability of the temporal mean PV yield for each latitude separately."

Figure 10 caption: Instead of "temporally" temporal variations.

We changed the word temporally to temporal in the caption of Figure 10.

Technical corrections were included into the manuscript.

References

Kothe, S., Pfeifroth, U., Cremer, R., Trentmann, J., and Hollmann, R.: A satellite-based sunshine duration climate data record for Europe and Africa, *Remote Sensing*, 9, 429, 2017.

Neher, I., Buchmann, T., Crewell, S., Pospichal, B., and Meilinger, S.: Impact of atmospheric aerosols on solar power, *Meteorologische Zeitschrift*, 28, 305–321, 2019.

Solargis: Solar Resource Map 2019, <https://solargis.com/maps-and-gis-data/download/africa>, 2019.

C5

Interactive comment on *Atmos. Chem. Phys. Discuss.*, <https://doi.org/10.5194/acp-2020-306>, 2020.

C6