

Atmos. Chem. Phys. Discuss., author comment AC2
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Reply on RC2

Jonas Witthuhn et al.

Author comment on "Aerosol properties and aerosol–radiation interactions in clear-sky conditions over Germany" by Jonas Witthuhn et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-517-AC2>, 2021

Dear Referee #2,

Thank you for your suggestions and remarks. Consideration of these comments have helped to improve the manuscript. Below you will find the answers to each comment.

We have changed the manuscript according to this technical corrections:

- L15. Assymetrie -> assymetry
- L53 Please provide the full abbreviation for ECOWAS, since it is not widely known
- 691 te -> the

Authors response to specific comments:

- Figure 2. It needs a little clarification. Some stations are missing the red dot and it is not clear their spot (eg Helgoland). Also, the symbol for sunshine duration is not comprehensible. How much sunshine duration is enough to get the symbol?
 - We now have ensured, that all station labels and their corresponding dots are visible. As indicated by the figure caption, the sunshine duration is only shown for DWD stations, as it is calculated from the measured irradiance. Therefore, no values of sunshine duration are shown for AERONET stations. We have clarified the figure caption accordingly: "Map of Germany showing the locations of DWD and AERONET stations. The sunshine duration is calculated from the measured irradiance data at the DWD stations and shown as accumulated hours for the year 2015. On the map ..."
- Paragraph 2.3 It should be clarified which level aeronet product is used in the study, since the uncertainties are different between lv 1.5 and lv 2.0.
 - Yes, we have clarified the used product levels. We use lv 2.0 for AOD and AE and lv 1.5 for SSA and ASY. See also the reply to RC1 (<https://doi.org/10.5194/acp-2021-517-AC1>)
- L237 For future studies, it would be interesting to have a more hybrid threshold, as a percentage of sunshine hours, in order to keep the day in the dataset. Since probably 2 hours in summer months it would not be representative, and at winter even smaller periods might be, specially for Northern Germany. For now I think it would be useful to show the percentage or number of days that fulfilled the criterion, at each station, in order to understand the representativeness of the conclusions.
 - The number of days which, according to our criterion, are sufficient for the CSF is

listed in Table 1. At L237 we added a reference to the Table.

- Since AERONET inversion products have a large gap around noon, how this interpolation take place in that case?
 - If the gap is larger than 90 minutes from the CAMS RA timestamp, then no valid pairing is found and the data of this timestamp is not considered in the comparison
- L364 The median value is from all data, per station or seasonal per station?
 - Referring to Figure 3, the median value is shown for all AERONET data points of AOD, AE, SSA, or ASY. No seasonality or different stations are considered here.
- Paragraph 4.1.1. How AERONET SSA is transferred to 550nm? If it through interpolation, a higher uncertainty should be considered. Also, I think it is important to provide a statistic of how many cases are misconsidered, due to the CAMS RA cut off at 1.5 AE.
 - The AERONET SSA is calculated using the inversion product. We are using the provided absorption AOD (AAOD) and extinction AOD at 440nm and the absorption AE (AAE) and extinction AE to calculate AOD and AAOD at 550nm using the Angström relation (Eq.(2)). With this, the SSA is calculated by $1-(AAOD/AOD)$. Oppositely, the CAMS RA SSA is calculated at 550nm from mass mixing ratios provided in the model level dataset using the aerosol optical properties' dataset. To test the influence of the AE cut off, we reproduced Figure 3 but excluding all data pairs (for SSA and ASY) of AERONET and CAMS RA if AERONET AE>1.6. This reduces the number of datapoints for the comparison of SSA and ASY from 19132 to 11682, which means that approximately 40% of cases are possibly influenced by this AE cut off. However, the results did not change much. For SSA, excluding cases of AE>1.6, the RMSE increases from 0.07 to 0.08 (see supplement of this answer - Figure 2). In the manuscript we added the statement on how the AERONET SSA at 550nm is derived and a possible higher uncertainty. Also, we added a sentence indicating that about 40% of cases are possibly influenced by the AE cut off.
- L397 I think that the explanation is not sufficient in order to consider the uncertainty of CAMS RA ASY. Relative error is more appropriate term for this quantity.
 - We agree, but as this is not a relative quantity, we now use the term "standard error" instead of uncertainty.
- L399. I suggest to show these results in the Appendix, for the inclusiveness of the study.
 - We have now added the results for the year 2015 as a figure in the appendix. In the updated manuscript, this will be Fig. A1.
- L523 Linke turbidity is not widely known term. Please provide a definition.
 - We now have added the following reference and definition to the Appendix section A2 and a corresponding reference at L523: "(Louche et al. 1986), which defines the Linke turbidity as the ratio of the optical depth of the atmosphere to the optical depth of a pristine atmosphere, excluding aerosols and water vapour."
- L547 it should be explained in detail, why this inequality is the appropriate measure for the agreement.
 - Here, the standard deviation of two predictions for the same observation are compared. As the reference data is the same for both predictions (pristine or with aerosols), the metric introduced in L547 is similar as comparing the coefficient of variation (relative standard deviation) of both estimates. Therefore, a lower relative standard deviation indicates a higher level of agreement of simulation and observation. As the simulation with aerosols is expected to show the higher level of agreement, the metric is defined in the way, that positive values of $\Delta\sigma$ indicate a better agreement if aerosols are considered. We agree, that the way Eq.(7) is introduced should be clarified. In the manuscript, we edited Eq.(7) to $\Delta\sigma = \sigma(F_{pri} - F_{obs}) - \sigma(F_{aer} - F_{obs})$, and in the text an explanation similar to this answer is added in the same paragraph.
- Figure 7 and 8. I guess, specially in winter, a lot of days have been interpolated, please provide some statistics about these cases.
 - Yes, a lot of days had to be interpolated during the year and especially in winter to

fill the gaps caused by cloudy days, which do not meet the CSF criterion. This is also indicated by Table 1, where the absolute number of days available for CSF are shown. We have now added Table A3 in the appendix, to show the relative number of days to be interpolated for the results in Sect. 4.2.3 (including Fig. 7 and 8). In the first paragraph of Sect. 4.2.3 we have added: "Note, numerous days had to be interpolated in order to fill the gaps in the CSM simulations caused by cloudy days which do not meet the CSF criteria (see Table 1 and Table A3).".

- Figure 11 I suggest to use a different color scheme, since it is difficult to see the differences at the stations. Also use a larger font on the map.
 - We agree, that for the annual mean values in Fig. 11 the color scheme could be spread out in order to enhance the visibility of details and comparison to observations at the stations. However, the color scheme is chosen to be fixed for Figures 11 and A4 to A7 in order to enhance the comparability of annual and seasonal means. Therefore, we would like to stick to the given color scheme for the revision of the manuscript. However, we increased the font size and station markers to improve the readability of the figures.
- Figure 12 Please explain how the classification of aerosols was made. It is nowhere to be found in the manuscript.
 - The aerosol classification is taken from the CAMS RA dataset. We have integrated the mass fraction of each aerosol type, taken directly from the model level data (see Bozzo et al. 2020). In addition, we have combined all size bin limits in order to simplify the pie charts to 5 aerosol types. We now have cited Bozzo et al 2020 in the Fig. 12 caption.

References:

- Bozzo et al 2020: <https://doi.org/10.5194/gmd-13-1007-2020>
- Louche et al 1986: [https://doi.org/10.1016/0038-092x\(86\)90028-9](https://doi.org/10.1016/0038-092x(86)90028-9)

Please also note the supplement to this comment:

<https://acp.copernicus.org/preprints/acp-2021-517/acp-2021-517-AC2-supplement.pdf>