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Reply on RC1

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-AC1, 2021

Dear Referee #1,

Thank you for carefully reading the manuscript and pointing out numerous technical corrections. The requested clarifications and references to ambiguities have also contributed to the improvement of the manuscript.

We have corrected the manuscript according to your advice. As we use the latex template to prepare the manuscript, the figure and tables are automatically placed. The correct placement of the figures and tables will hopefully be resolved in the final typesetting phase.

Apart from many technical corrections, Referee #1 pointed out some ambiguities and asked for comments from the authors. These comments are answered below:

- L167: Have the authors used the Level 2 AERONET product?
  - Yes, the level 2.0 (quality assured) data is used in case of AOD and AE. For the inversion products, SSA and ASY, we had to fall back to level 1.5 (cloud-screened and quality controlled) data, as level 2.0 data was only available to a limited extent. In any case, the AERONET Version 3 database is used. We have improved the description of the used AERONET datasets accordingly.
- L169: Do the authors refer to standard or to expanded uncertainty?
  - The uncertainties of SSA and ASY refer to the U27 lookup table results. These are provided with in the ancillary data of uncertainty estimates for each product and refer to a variation within one standard deviation. In the manuscript we now use the term "standard uncertainty".
- L384: Given that the AOD values are low over Germany, the authors have possibly used the Level 1.5 AERONET inversion products (which should be specified here).
  - Yes, this is correct. We now have added a statement about the used product level.
- L488: In the case of MBE the AOD uncertainty is less significant than the AE uncertainty
  - We have rewritten this sentence accordingly: "For irradiance and REari, the major contribution to the MBE is the SSA uncertainty, and to the RMSE the AOD and SSA uncertainty of CAMS RA."
- Table 3: It looks that the performance of the Solis simple model is generally better than that of the other models (at least regarding MBE and RMSE). Please comment.
  - The Solis simple model is based on explicit radiative transfer simulations for selected situations. These include simulations with an AOD value of 0. Therefore, it is not

surprising that ecRad and Solis simple agree well under pristine conditions (AOD=0). All other CSMs do not explicitly include a pristine case as implemented in Solis simple. They are mostly optimised to represent the measured irradiance under natural conditions, which of course always contain some aerosol content. The explanation in Sect.4.2.1 on this topic has been extended accordingly.

- L565: Can the authors assume why the best agreement is found for the referred cases?
  - These results can be explained for several reasons. First, the stronger solar radiation and the more absorbing aerosol in spring and summer lead to a mitigation of the systematic errors in the simulations (e.g. overestimation of absorption by CAMS RA) and measurements. In addition, larger AOD values are observed in spring and summer and at more northerly stations, which reduces the deviations due to random errors. Furthermore, the input data of CAMS RA are collocated and altitude-corrected for this comparison, and the uncertainties of this method are larger over complex terrain and mountains towards the south. However, the differences in the various selection criteria are very small, so these are only hypotheses. This explanation has been appended to the manuscript.
- L570: "except for winter and fall seasons". Any possible explanation?
  - This could be due to the lower absorption properties of aerosol in winter and fall and generally lower AOD values in these seasons. Reduced absorption by aerosols leads to increased deviations due to overestimation of absorption in CAMS RA. Lower AOD values also mean a weaker radiation effect, making the simulation more prone to random errors. This explanation has been added to the manuscript.
- L612 – 613: "To avoid ... surface albedo". I did not understand what the authors did here.
  - The default simulation using T-CARS rely entirely on the input data of the CAMS RA. This includes also the surface albedo. On the other hand, simulations done with the CSM purposely avoiding CAMS RA as input source and thus the high resolution surface albedo data form LSA SAF is used here. However, for the comparison of surface REari to AERONET and CSM based simulations, the REari from the CAMS\,RA input is adjusted to avoid inconsistencies of different surface albedo used for the calculations. As Eq.(1) can be reformulated at surface level using the surface albedo (α_{sfc}) by:
    $\Delta F_{sfc} = (1 - \alpha_{sfc})\,(F^{\square}_{sfc,aer} - F^{\square}_{sfc,pri})$,
    the adjusted CAMS RA REari ($\Delta F'$) is calculated as follows:
    $\Delta F' = \Delta F_{sfc}\,(1 - \alpha'_{sfc}) / (1 - \alpha_{sfc})$,
    where α'_{sfc} denotes the requested surface albedo of either AERONET or LSA SAF as used for CSM simulations. This explanation has been added to Sect.3.3.2 and subsequent references has been added to part of the text Referee\#1 is referring to.