

Review of the paper “Radiative and climate effects of aerosol scattering in long-wave radiation based on global climate modeling” by Drugé et al.

The manuscript explores the impact of neglecting the representation of aerosol scattering in the longwave spectrum on the simulations of a Global Climate model. The radiative impact of longwave aerosol scattering is analysed using a 30-year integration of the ARPEGE-Climat atmospheric global climate model with prescribed boundary conditions. The authors analyse a set of model variables and their change between the simulation that includes longwave scattering and the simulation neglecting it.

The topic is of certain interest to improve the quantification of the uncertainty in aerosol radiative forcing on the Earth radiative budget and of the role of assumptions in the radiative transfer modelling. The paper is well organised and the methodology sufficiently clear.

My main issue with the current version of the manuscript is a lack of in-depth analysis of some of the main impacts observed when aerosol longwave scattering is enabled in the radiative computations. In particular, the change in low and high cloud fraction displayed by the model is puzzling because no mechanism behind it is discussed. Previous studies (e.g. Dufresne et al. 2002) suggest that the impact of longwave aerosol scattering on the heating rate profiles is relatively small: is this the case also in this study? Modification in the lower atmospheric stability is mentioned as one reason to explain the increase in low level cloud fraction. It would be interesting to see model data to support this hypothesis. Are surface temperature changes such as the ones reported here, enough to sustain the observed modification in the cloud fraction? Or is there any other feedback at play?

I think that to support the conclusion that climate simulations should explicitly include longwave aerosol scattering, a more complete description of its impacts on the model fields would be helpful.

The language throughout the text is generally clear, but I suggest a double check to improve the text in places (few suggestions in the specific comments below).

Specific comments:

Abstract, line 1: “The few studies that considered aerosol scattering in the long-wave (LW) typically relied on artificially increasing it.” Please explain or rephrase, it is not clear what it is meant by “artificially increasing it”

Abstract, line 8: “in line with the maximum coarse AOD” please clarify, e.g. “correlated with the largest AOD from coarse particles.”

Abstract, line 10: “However, during certain months and regions” -> “However, during certain months and in certain regions”

Introduction, page 1, line 22: please indicate the reference for AR5. Also, AR6 should be explained above, where there is the first reference for the latest IPCC Assessment Report.

Introduction, page 3, line 64: Values in Dufresne et al. (2002) are for specific profiles and not global means though, right?

Section 2.2: In the discussion of the results, the impact of the longwave aerosol scattering is shown for all-sky and clear sky conditions. Perhaps it could be mentioned here how the two contributions are calculated (i.e. selecting clear sky areas or with separated clear sky computations?)

Section 3, line 192: Differences in the RI for wavelengths above 20 microns is likely of minor importance: do spectral regions outside the IR window contribute significantly to the results shown in this study? Generally, only for extremely dry atmospheres the radiative effect of longwave scattering from aerosols is significant for spectral regions above 20 microns.

Section 3, line 196: Since the sea salt results are not discussed, perhaps this can be removed/shortened?

Section 5, line 251: Please clarify what is it meant “this daily minimum surface temperature increase is much smaller than the extent of the LW surface radiation increase.” Does this refer to the area showing changes respectively in LW fluxes and surface temperature or the magnitude?

Section 5, line 254 and 269: These results could be interesting and deserve more in-depth analysis in my opinion. Is there an interaction with the strength/position of the ITCZ or/and the West African Monsoon region? Also, this is the region where there is a significant negative bias in AOD compared to AERONET, does this have an impact on the results?

Section 5, line 282: “In clear-sky conditions, LW scattering of aerosols has less impact on radiation.” Doesn’t this contradict what said at line 247 “Our results indicate that they are even more significant in clear-sky conditions?” Please clarify.

Section 5, line 290: This makes the simulation results interesting but somewhat difficult to interpret. As far as possible within the current simulation, physical interactions between model variables should be analysed.

Conclusions, line 313: “for turning on or off the 3D scattering of aerosols in the LW.” What is it meant by 3D scattering?

Conclusions, line 313: This information is mostly auxiliary to the current study, and I would not mention it in the main conclusions which should be focussed on the mean results of the impact of the explicit treatment of longwave scattering in aerosol radiative effects.

Conclusions, line 334-338: An estimate of the different weight of these contributions to the general longwave aerosol radiative forcing would be interesting, to put in context the size of the effect analysed here. It could be added to the main discussion.

Figures

Figure 3: From the caption it sounds like the first column shows AOD differences, which had me confused. Please rephrase.

Figure 4: the symbols r_{lds} and r_{lus} have never been defined.

Figure 5: The colours in the second panel are not very clear and it is difficult to discern the various lines. It is also not very clear what it is meant by “No significant changes in confidence intervals indicated in light color”. Is the light colour shading indicating the confidence interval or the significance of the differences between the two runs? How is this computed? Please clarify here or in the mean methods section.

Figure A3: it should be “same as Figure 4”