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Comment on acp-2022-350

Anonymous Referee #2

Referee comment on "Size-resolved dust direct radiative effect efficiency derived from satellite observations" by Qianqian Song et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-350-RC2, 2022

This paper develops a dust direct radiative effect efficiency (DREE) climatology that is based upon the dust aerosol optical depth (DAOD). The purpose of the climatology is to allow a quick computation of the dust direct radiative effect (DRE) from the DAOD, which can be inferred from satellite datasets such as CALIOP. I think that this is a good paper that is suitable for publication, but I struggled a bit with the methodology.

Size-dependent SW and LW DRE are computed from the Rapid Radiative Transfer Model (RRTM) for six dust models with 10 size bins. The dust models include three complex refractive indices (low, medium, and high) and two shapes (spheres, spheroids). The real and imaginary refractive indices are coupled (low RRI is paired with low IRI, etc).

The RRTM is used to simulate monthly mean DRE using CALIOP DAOD; apparently this is done for each size bin (per line 273). As near as I can tell, though, all of the DRE calculations use the CALIOP DAOD for the computations, per Eq 1 and line 301. This isn't helpful for computing the actual DRE associated with the atmospheric state, except that the authors are targeting DREE (not DRE). Thus, their argument seems to be that the DREE of the different size bins are not coupled. I am ok with that, except

1.) why do you need CALIOP DAOD to do this? Why not just compute DAOD and DREE from the size and RI that you used to compute DRE? Perhaps that is what is being done, but the writing was not clear to me.

2.) is it really necessary to carry water vapor, ozone, and CO2 in the DRE calculations of Eq 1 when we are assuming that the aerosols in the 10 size bins are decoupled (and hydrophobic)? There is much overlap in the extinction efficiencies in Fig 3, so I would expect that the neighboring size bins have a significant influence on the radiation field (in the SW, at least).

It is quite possible that I read Section 3.1 incorrectly, though. However, that means that other people might struggle as well. I recommend clarifying Section 3.1. This probably won't take too much effort if you focus on describing Figure 4, which makes sense to me.

How many streams are the authors using in the RRTM? Apparently they are using a two-stream approximations (since they are using asymmetry parameters and not using phase functions). This needs to be mentioned.

Since you are using CALIOP DAOD, I think that there should be some discussion about the CALIOP lidar ratio assumption. For instance, CALIOP uses a single lidar ratio for dust worldwide, and this will contribute to the regional CALIPSO/MODIS DAOD bias (that the authors mention on page 6) if the real-world dust lidar ratio varies regionally. A regionally-variable lidar ratio could be caused by regionally variable mineralogy, which would also cause regionally variable refractive indices. This would also impact how the tables should be applied. For instance, one would want to assume the highest imag refractive indices in dust regions with the highest proportions of iron.

Why are the maps in Figure 1 so small?? It is really difficult to concur the text with the figures on page 10 when the authors are using so small of a figures. You might also consider replacing these maps with a difference map, since you are mostly discussing differences between the two maps in the text.

MINOR POINTS

Real and imaginary refractive indices are not necessarily coupled. Thus, high real indices don't necessarily pair with high imaginary refractive indices. No need to change methodology on this point, but that should be mentioned.

line 204:

Authors refer to another paper for the two dust shapes, but the two shapes are merely spheres and spheroids. Why not just tell the reader such simple info up front?

Line 305:

Eq 2 should immediately follow its introduction (i.e., immediately follow first sentence on line 305).

Line 312-4:

Likewise, Eqs 3 and 4 should immediately follow their introduction.

Fig 2 caption:

Briefly tell the reader the where you found these refractive indices (e.g., Di Biagio 2017, 2019; Balkanski 2007).

Fig 3 caption:

Define the y-axis variables in the caption.

Fig 8

Here again, I think that difference plots would be stronger than requiring a reader to surmise the differences between lines on a rather small y-axis.

Figure S1 and S2 are way too small to be at all useful.