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Comment on acp-2022-350

Anonymous Referee #1

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-RC1, 2022

This study developed a global dataset of direct radiative effect efficiency (DREE) of mineral dust for ten dust size bins with geometric diameter from 0.1 μm to 100 μm, three sets of refractive indices (weak, mean, and strong absorbing), and two shapes (spherical and spheroidal). The monthly DREE dataset is derived from the Rapid Radiative Transfer Model (RRTM) model using CALIOP-based dust aerosol optical depth (DAOD) and vertical distribution along with atmospheric profiles from MERRA-2 and surface variables. The global direct radiative effect (DRE) of dust aerosols is then examined using the DREE-integration method and DAOD climatology from CALIOP and MODIS, respectively. It is found that different spatial distributions of DAOD may contribute to about 10% differences in shortwave DRE of dust even with the same global mean DAOD. The calculated DRE is also sensitive to refractive index (RI) and particle size distribution (PSD) but much less affected by dust shape. Improving the estimation of the DRE of dust is essential to reduce the uncertainties of radiative forcing of aerosols to the climate system. This observation-based study and newly developed dust DREE dataset will provide a useful tool to constrain model simulations and study dust DRE. Overall, the paper is very well written, with thorough description and analysis of DREE calculation, validation, uncertainty, and comparisons with previous studies. I have some minor comments for the authors to consider.

- Section 3.1, it's not clear here which version of PSD is used in the calculation. Moving the information about PSD in lines 467-468 to here could be helpful.
- Line 295, is the DRE^{SW} a vertical profile?
- Line 306, please add more details about surface emissivity. Is it also from satellite retrievals?
- Line 394, what about the uncertainties of ignoring the horizontal variations in dust particle size due to different dust lifetime?
- In the simulation where Fennec-Fresh PSD is used in the dust belt (covering dust sources in the Sahara, Middle East, and eastern Asia) and AER-D PSD over other regions, it's interesting that shortwave DRE are much smaller over dust sources in the Indian subcontinent and Taklamakan Desert (Fig. 10), although DAOD is relatively high

in these regions in both CALIOP and MODIS (Fig. 1). Can you comment on this?

- Line 676, consider providing more information about the dust RI used by Kok et al. (2017) for a brief comparison.