We thank you for taking the time to review the manuscript and for your helpful comments. We have revised the manuscript in response to your comments. We believe that the manuscript has been greatly improved thanks to your suggestions.

A nice structured work, developed by the utilization of CALIOP and MODIS retrievals for the establishment of a global aerosol-speciated 3D distribution. Typical aerosol properties are derived and collocated against ground-based stations (AERONET). Finally, SDRF values (under clear sky conditions) are retrieved and compared against results in previous studies for the estimation of aerosol induced perturbations on the Earth-Atmosphere radiation budget.

1 Introduction

I think the revised V4 types of CALIPSO and some weaknesses of CALIOP and MODIS retrievals - not only the limited wavelength information and the strong surface reflectance, respectively - should be mentioned (these preferences would probably have a reasonable contribution to the uncertainty in some CALIOP-MODIS retrievals).

We revised the sentences as follows: “The columnar properties of aerosols are available from the MODIS multi-wavelength information, and τ_a is retrieved accurately (e.g., Shi et al., 2019), but aerosol vertical profiles cannot be obtained, and strong surface reflection (e.g., snow, desert) makes the retrieval difficult (Hsu et al., 2013). CALIOP observations exclude the data at the layers contaminated by the surface reflection and provide information on the vertical profiles of aerosol optical properties and particle shapes (spherical/non-spherical), but only limited wavelength information. Additionally, CALIOP does not detect the tenuous layers in the daytime due to the low signal to noise ratio. This results in the underestimation of τ_a (Omar et al., 2013; Kim et al., 2018). The synergistic use of both instruments decreases the influences of the surface reflection and provide the more accurate columnar properties and vertical profiles of aerosols. Furthermore, the particle size information is obtained from the combined spectral information of the CALIOP and MODIS observations (Kaufman et al., 2003).”

5 Retrieval results from the CALIOP and MODIS observations in 2010

In Figure 8 the different strong aerosol sources (e.g. dust source in the region of Bodélé) are not visible. For example, a well-known problem of CALIOP-CALIPSO retrievals is the sufficient underestimation of AOD over strong aerosol sources, an inadequacy strongly related to the presence opaque layers completely attenuating the laser beam. Probably a colorbar with a lower AOD limit (less than 0.8) or with modified bins or just a different colorbar could help with the visualization of this result. If a filter is applied for the smoothness of the colors on the map, this filter maybe contaminates the AOD over the sources especially if the surrounding regions have substantially lower AOD.

Thank you for your advice. The color bars of Fig. 8 have been modified to emphasize the spatial variations. The dust source of Bodélé was clear in the MODIS result (Fig. 8c). Although the CALIOP-MODIS retrieval utilizes the MODIS measurements, the dust source was not clear in the CALIOP-MODIS and CALIOP results (Figs 8a and b). We think the sparse observation of the CALIOP in the longitude direction may be a possible cause. This discussion was added in the revised manuscript.

In Figure 9 an aerosol-speciated distribution is not clear. It's like having 2 groups of SSA values (land-ocean). A narrower colorbar (starting e.g. from 0.8) could help with the distinguishing of some areas. For example, over the Northern and the Central Africa a lower and a higher SSA value should be visible (dust and more absorbing particles-like smoke from biomass burning- respectively). The same problem is visible for AF.

The color bars of Figure 9 have been modified, and the spatial variations were discussed in the revised manuscript as follows: "Figure 9 shows the horizontal distributions of ω_0 and g of the CALIOP-MODIS retrieval. The global means of ω_0 and g were about 0.940 $\pm$ 0.038 and 0.718 $\pm$ 0.037. Previous studies have shown that the global mean ω_0 is from 0.89 to 0.953 (Korras-Carraca et al., 2019; Kinne, 2019), and the global mean g is 0.702 (Kinne, 2019). Our results are thus consistent with these previous studies. ω_0 over the land was from 0.8 to 0.95 and was smaller than that over the ocean. g over the land was from 0.6 to 0.75 and also smaller than that over the ocean. These differences between land and ocean are due to the presence of SS over the ocean, because ω_0 and g of SS are larger than those of the other aerosol components (Table 1). In the major biomass-burning regions of the central and southern parts of South America, and the southern part of Africa, ω_0 and g of the CALIOP-MODIS retrieval are particularly small, from 0.85 to 0.90, and 0.65 to 0.70, respectively. These are consistent with the results of Kinne (2019). However, our retrieved ω_0 is less than 0.90 over the most parts of the land area and appears to be about 0.05 smaller than ω_0 of Kinne (2019). In Sect. 4, it was shown that the CALIOP-MODIS retrieval tended to underestimate ω_0. The tendency to underestimate ω_0 might appear in the retrieval over the land."

In Figure 12 it's not clear for me some hotspots of coarse DS particles over the Norway and Sweden

The color bars of Figure 12 have been modified. There are two hotspots over the Norway and Sweden. However, there are no major desert region in Norway and Sweden, and the dust AOD is small in Fig. 10c. The uncertainties of the retrievals become large in the small AOD cases, and the particle radius of DS tends to be overestimated (Fig. 6l). The particle radius of DS would be overestimated at the hotspots. There are many hotspots in Fig. 12c, and the retrieved particle radius of DS deviates significantly from the AERONET data (Fig. 13f). We need the further investigations of validation and quality control.

In Figure 13 AOD shows a good agreement with AERONET, but the other parameters rather deviate. In

comparison with Figure 9 maybe the results for the other properties need further investigation, since these parameters are also used for the radiative simulations and furthermore for the heating rate.

In this study, we used only the data in 2010. We are now processing the data from 2007 to 2021, and we will conduct the intensive validation study using the ground-based networks of AERONET, SKYNET (sun/sky photometer), and AD-Net (lidar). We will improve the constraints and assumptions in the CALIOP-MODIS retrieval after the validation study.