Respond to Reviewer #2

Dear reviewer, thank you for your useful comments. We have carefully analyzed your comments, and replied to your comments point by point and included corresponding modifications in the manuscript. In the following text, your comments are marked in bold italics, our responses are in black, and the modifications in manuscript are shown in blue.

Highlights
- alternate aerosol retrieved by a new satellite sensor with the GRASP algorithm
- investigations of relative relevance of particular sensor data on retrieval accuracy
- comprehensive evaluation

Thank you for the comments. The DPC is the first multi-angle polarized sensor in China and this study is to estimate its performance for aerosol monitor. We hope and believe China's satellite product will be improved with continuous developments and publicly released.

Concerns
- still significant differences in spatial distributions
- with all the extra sensor information … no superiority compared to existing retrievals
- missing absorption and size evaluations, hinder meaningful AOD retrieval assessments

Thank you for the comments. We agree with your concerns. In addition to the use of new retrieval methods, the differences in spatial distribution of AOD is probably also related to other factors including different orbitals, narrower swath width [1] (1850 km of DPC, while that of MODIS is ~2300 km), and cloud mask. Since, only a limited set of DPC data (1/3/2020 to 10/4/2020) is used in our application and thus time span is not large. The AERONET retrieval of complex aerosol optical properties (SSA, etc.) use sky-scanning measurement that are less frequent than direct triple observation of the sun (for only AOD). Therefore, only few matches between DPC and AERONET could be obtained in the range of 25 km/30 min. More importantly, the current study is mainly a preliminary attempt to analyze the DPC data that were strongly compromised by 20% bias… Therefore, our analysis is mainly dedicated to base aerosol parameters such as total AOD, since the retrieval of more detailed properties generally requires very high quality observations. Nonetheless to address the comments we provide the **Figure** below showing preliminary comparisons between daily average SSA and fine-mode AOD from DPC GRASP/Models and AERONET data, as a brief assessment of aerosol absorption and size information. Overall, the result are somewhat comparable to the POLDER-3 GRASP/Models results reported by Chen et al 2020 [2]. Also, as discussed by Chen et al. (2020) it can be noted, that the GRASP/Models was the approach that provided the least accurate retrieval of details aerosol parameters (SSA and AODF) while was the best for AOD.

We hope this illustration can, at least, partially address your concerns. We will make continuous efforts in the future to data quality and usability of Chinese sensors.

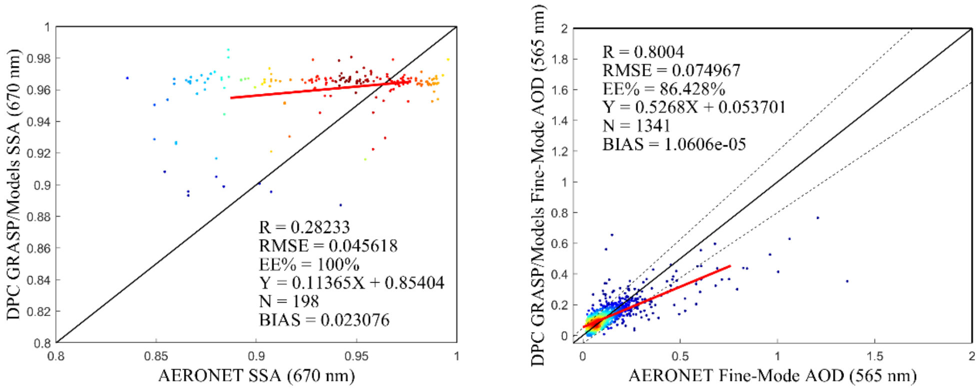

Figure. Comparisons of daily SSA and fine-mode AOD from DPC GRASP/Models and AERONET.

[1] Li, Z., Hou, W., Hong, J., Zheng, F., Luo, D., Wang, J., Gu, X., & Qiao, Y. (2018). Directional Polarimetric Camera (DPC): Monitoring aerosol spectral optical properties over land from satellite observation. Journal of Quantitative Spectroscopy and Radiative Transfer, 218, 21-37, doi:10.1016/j.jqsrt.2018.07.003.

[2] Chen, C., Dubovik, O., Fuertes, D., Litvinov, P., Lapyonok, T., Lopatin, A., Ducos, F., Derimian, Y., Herman, M., Tanré, D., Remer, L.A., Lyapustin, A., Sayer, A.M., Levy, R.C., Hsu, N.C., Descloitres, J., Li, L., Torres, B., Karol, Y., Herrera, M., Herreras, M., Aspetsberger, M., Wanzenboeck, M., Bindreiter, L., Marth, D., Hangler, A., & Federspiel, C. (2020). Validation of GRASP algorithm product from POLDER/PARASOL data and assessment of multi-angular polarimetry potential for aerosol monitoring. Earth System Science Data, 12, 3573-3620, doi:10.5194/essd-12-3573-2020

General comments

A GRASP-based retrieval algorithm is applies to a new Chinese satellite sensor operating since 2018. The Directional Polarimetric Camera (DPC) is a multi-spectral, multi-angle and also polarization sensing instrument to offers a wealth of information about atmosphere and surface. All this information is processed in a statistically optimized GRASP retrieval for a consistent determination of surface and all aerosol properties at cloud free condtions. Retrieval results for AOD are compared to AERONET local statistics and different MODIS versions and indicate general skill. However, AOD spatial distribution samples still leave many questions open. For a more comprehensive AOD comparison/evaluation – especially for comparisons to other satellite data complementary information on aerosol size (e.g. AOD finemode fraction) and absorption e.g. AAOD or even better AAOD attributed to fine and coarse mode) would go a long way. Otherwise, a nice contribution

Thanks for the thoughtful comment. GRASP is the most notable algorithm to this problem, and it has good prospects and has shown convincing results in POLDER-3. Therefore, we decided to follow it. Nonetheless, we agree that obtaining good retrievals of detailed aerosol optical and microphysical need more efforts especially taking into account the current known issues with DPC data availability and quality (20% bias, etc.). Thanks for your understanding, we will continue to work on this in the future.

Specific comments

251 are these effective radii (in um)? Since the size-modes are represented by log-normal

distributions what are mode(-number) radius and std dev (width information)? For dust regions I would allow another super-large (e.g radius ca 6-9um) dust size, as large size mineral dust, if present, will add significant absorption, which otherwise may be incorrectly attributed to finemode aerosol

Thanks for your comments. These are the mode radius rather than effective radius. In the module of GRASP/Optimized, the aerosol size distribution was fit by 5 lognormal bins with mode radii of 0.1, 0.1732, 0.3, 1.0, and 2.9 μm, and mode standard deviations of 0.35, 0.35 ,0.35, 0.5, and 0.5, correspondingly. It should be noted that the contribution of the supper large particles is accounted in those bins. As for the retrieval of details of size concentrations for those super large particles, such retrieval would over ambitious, since the information content in reflected radiation measured from space is rather limited for this ambitious task. This aspect was discussed by Dubovik et al. (2011) and therefore number of parameters of describing the size distribution was significantly reduced for satellite retrieval compare to AERONET retrievals (see also Dubovik et al., 2021).

[1] Dubovik, O., Herman, M., Holdak, A., Lapyonok, T., Tanré, D., Deuzé, J.L., Ducos, F., Sinyuk, A., & Lopatin, A. (2011). Statistically optimized inversion algorithm for enhanced retrieval of aerosol properties from spectral multi-angle polarimetric satellite observations. Atmospheric Measurement Techniques, 4, 975-1018, doi:10.5194/amt-4-975-2011

322 …which is common for aerosol retrieval with most sensors

Thanks for the thoughtful comment. Would you mean general principle for aerosol retrieval? In the forward model of GRASP, surface reflectance is modeled by Ross-Li BRDF and Nadal BPDF, and aerosol is modeled by considering complex optical and microphysical properties. There are no fixed assumptions. To avoid misleading readers, we also revised the text.

Line 268-273

The initial guess of aerosol and surface properties are default in the GRASP software. They are applied to calculate AOD at a global scale. The Ross-Li's model (Li et al. 2001) and the Cox-Munk model (Cox and Munk 1954) were used for modeling radiative (non-polarized) reflectance over land and ocean, respectively, while, the surface polarized reflectance followed the method of Nadal and Bréon (1999). More detailed description can be found in Dubovik et al. (2011),

439 yes as this is kind of a pre-cursur to ESA's upcoming 3MI space sensor

Thanks for your comments. Yes, I learned about the 3MI through the official website. This is a wonderful project that we are looking forward to.

647 show, in addition, the same results side-by side in a log/log scale so info on behavior at low (or most coomon) AOD is better illustrated (the linear fit is less meaningful, as controlled by a few larger values)

Thank you for the suggestions. We agree that presentation in log scale provides some additional inside on the error distribution, therefore we have added such figures. The added figure in the manuscript as shown below. At the same time, we are not sure if this representation will be fully convincing for the readers as we have rarely seen the log scale coordinates before, therefore we keep original figures too.

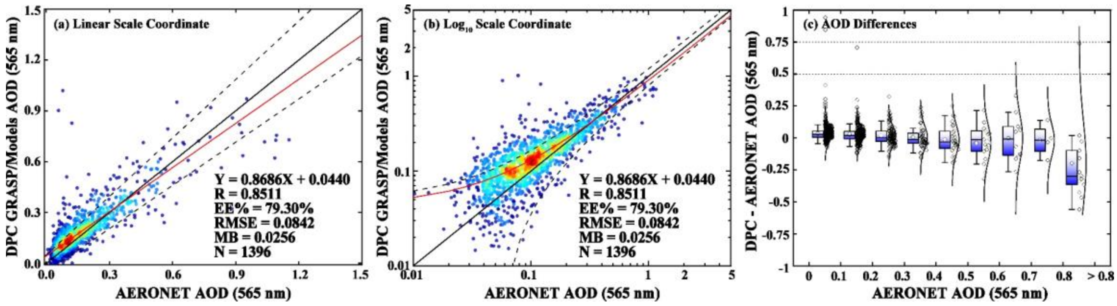

Figure 2. (a) Density scatterplot of AOD retrievals from DPC with the GRASP/Models scheme versus the AERONET observations with a linear coordinate system. **(b)** The density scatterplot with a logarithmic coordinate system. The solid black line is the one to one and the dashed black lines show the ranges of Expected Error. The red solid lines represent the linear regression line; **(c)** Box plots show changes of differences between DPC GRASP/Models and AEROENT with AOD increasing. Diamond marks and curves represent distributions of sample and normal distribution fitting lines, respectively.

651 nice … what about statistics at 1 or 2 (like SLSTR) viewing angles?

Thank you for the suggestions. In this study, we performed cloud screening separately for different angles, since they were not registered at the same time exactly. We further removed those data that only had 1-2 observation angles, in order to prevent the influence of cloud edges. From the principle of GRASP, if new observational errors will not be introduced with increasing number of angles, it is beneficial to the retrieval of complex properties of aerosols. Therefore, it is expected that, unilaterally, the retrieval performance of the retrieval using multiple angles should have benefits compare to use of 1-2 angles is weaker than that of, but it should be enough for only AOD retrieval in GRASP.

658 the 4b figure is so much better to understand than figure 4a! If there would be similar 4b plots for regions this would be perfect.

Thank you for the suggestions. We have added AOD difference figures between DPC GRASP/Models and MODIS DT, DB, and MAIAC products, as shown below. We hope this can add some quantitative statistics to our study.

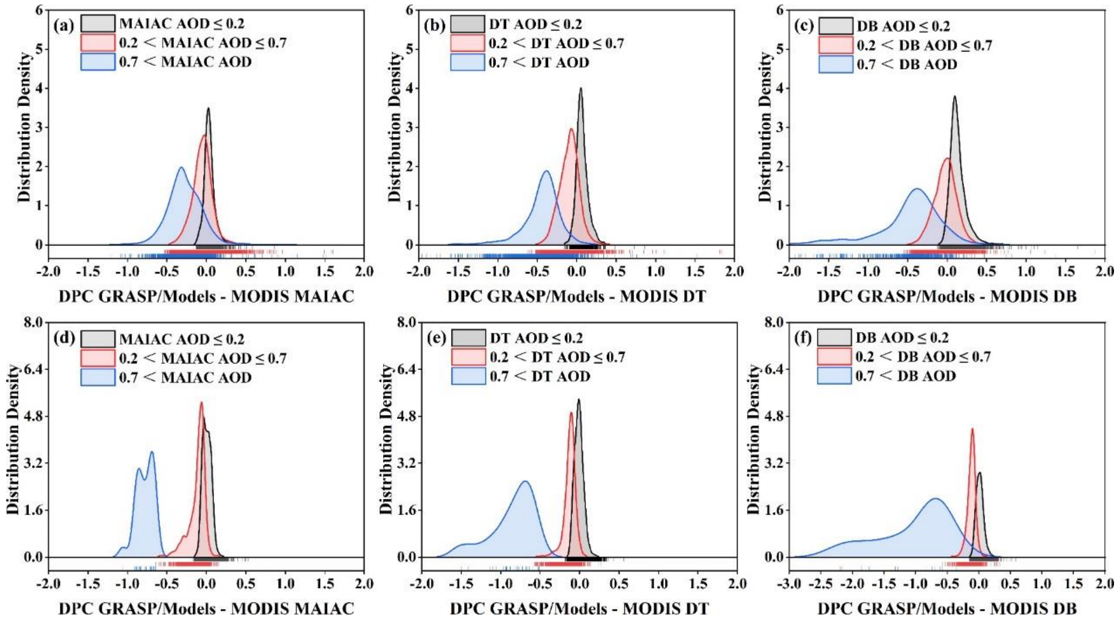

Figure 7. Distribution Density of AOD differences between DPC GRASP/Models and MODIS DT, DB, and MAIAC products at: **(a-c)** Eastern and Southern China with its adjacent sea areas; **(d-e)** Areas of Western Europe including the Atlantic Ocean and the Mediterranean. It is noted that the MODIS DB product only releases terrestrial AOD data.

668 the comparisons to other satellite data is an eye-opener. There ARE differences that need more attention. It is interesting that for E.Asia MODIS DT greater than MODIs DB, while it is the other way around for western Europe. I also would add MISR data (the are available) for the same region I attach a seasonal subset of a general (year-independent) MAC reference, which addresses aerosol amount, size and absorption (not just AOD !) for testing satellite retrievals, to identify major retrieval biases (which can be quickly done, if monthly 1x1 averages are provided).

Thanks for your comments. In terms of spatial analysis, the differences may come from the shorter time span, which is affected by the amount of approved data. Such short-term and large-scale analyses are relatively rare, so we did not want to expand the scope of this study to draw an inappropriate conclusion.

The MISR is a multi-angular detector that can obtain aerosol-scale information. Whereas, our initial investigation indicates that there is a clear systematic underestimation of its AOD in aerosol high loading regions, thus have not considered it for now. In addition, we noticed that a new generation research algorithm optimized for MISR has been proposed (https://amt.copernicus.org/preprints/amt-2022-95/). That study well solves the problem by using a priori MODIS/MAIAC BRDF dataset for high aerosol loading cases, and we are also very much looking forward to its new aerosol product.

Finally, for further complex aerosol optical properties (size and absorption), we calculated them with DPC GRASP/Models as shown following. It must be stated that retrieval of aerosol complex properties depends on to high-quality observations. Since the DPC has large bias, the figure below is just a preliminary result for only reviewing. I used a similar color to your figure for better contrast, and the 10AAOD means ten times of AAOD (10AAOD = 10 × AAOD). I hope this can partially resolve your confusion. The current study is only a preliminary attempt. We will make continuous efforts in the future to data quality and usability of Chinese sensors.

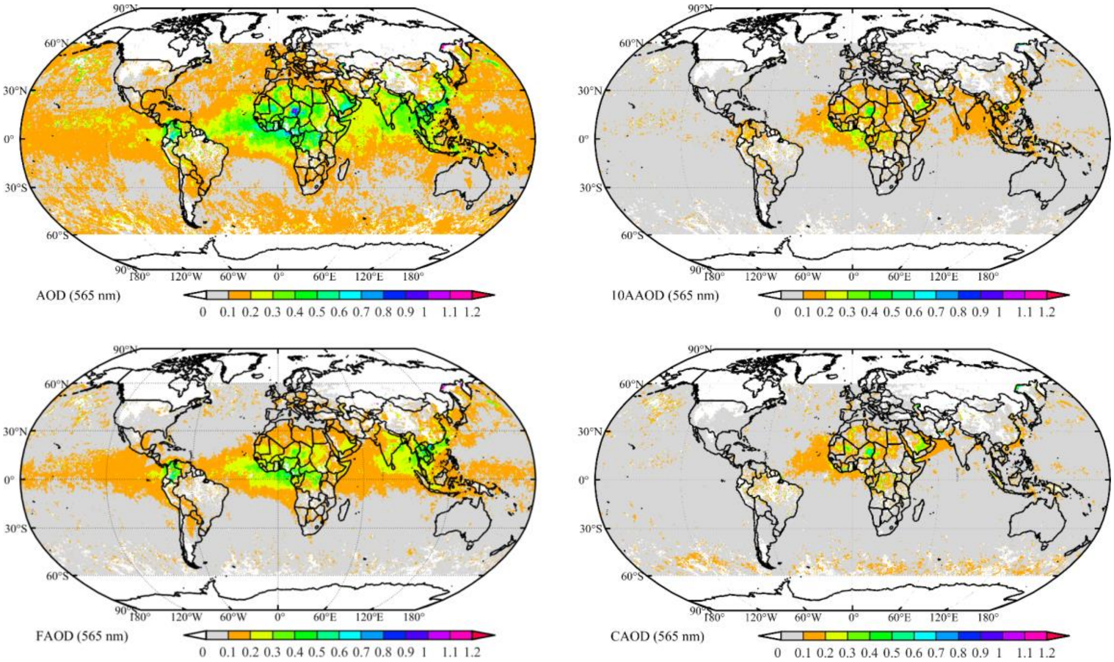

Figure. Distributions of AOD, 10AAOD, Fine-mode AOD, and Coarse-mode AOD retrieved from DPC GRASP/Models during 01/03/2020 to 20/03/2020. I guess the 10AAOD in your figure means ten times of value of AAOD.