Round 2：Respond to Reviewer #2

Dear reviewer, thanks for your comments. We have carefully read your comments, and replied to your comments point by point with corresponding modifications in the manuscript. It is no doubt that your comments are very important to us. In the following, your comments are marked in bold italics, our responses are in black, and the modifications in manuscript are shown in blue.

Thanks for the nice response to my review.

Given the limited data (not even a year) it is understood that evaluations are somewhat limited. Although the general approach is promising, the admitted 20% bias indicates the need for significant improvements (maybe that can also be stated in the abstract).

Dear reviewer, thanks for your comments. Yes, this bias was a big problem in our research. But considering that the calibration bias of DPC is the main conclusion of another published paper, we do not emphasize this in our manuscript. But in the error analysis, we must point out the influence of this deviation.

The offered comparison of retrieval SSA and fine-mode AOD to Aeronet are quite interesting. The SSA comparison indicates that retrieval AOD are likely too low (in case of absorbing aerosol). This also can explain that AODf is mainly too low in case for major (absorbing) wildfire/pollution cases.

Dear reviewer, thanks for your comments. Yes, it is not excluded that this is the reason for the underestimation of AOD under heavy aerosol loading conditions. The retrieval of aerosol absorption and scattering abilities have always been a challenge, and in any case, from the results, the SSA of GRASP/Models are not optimal among different GRASP implementations.

On size, AERONET size-distributions cover radii up to 15um, although with limitations of degradation for concentrations of radii of above 5um. Mode radii are given with respect to number of volume which is why I prefer eff.radii. When the mode radii you listed with respect to number than Rmode 2.3 is close to reff 5um then no complaints, but if R-mode is with respect to volume (reff is then smaller) then an important big (and solar absorbing) dust size is missed in the retrieval.

Dear reviewer, thanks for your comments. Reviewer 3 is also interested in this question. But in the current version of GRASP, the development team hopes to retrieve aerosol parameters using consistent assumptions and constraints in the global. Therefore, a specific aerosol type which only appear in a unique environment have not been considered. Of course, region-specific optimizations should not be excluded either, and we will continue to consider this issue in future research.

Figure 2 is now much better. Retrieval overestimations at low AOD, as in most retrievals, is confirmed (what happended in case of negative AOD or is this not an option?)

Dear reviewer, thanks for your comments. Yes, the negative AOD is not an option in the GRASP. In iterations, all parameters must obey strict physical bounds in the GRASP. Currently, the slightly overestimations of AOD under low aerosol loading conditions is ubiquitous in GRASP, and similar phenomenon also occurs in results of POLDER-3/GRASP.

Figure 7 shows that high AOD cases are missed (in part as they are also probably more absorbing than the retrieval allows, as the SSA comparison to AERONET demonstrates).

Dear reviewer, thanks for your comments. Yes, we agree with you too, and we will look into this further in future research.

The comparisons between AOD, 10*AAOD, AODf and AODc are quite interesting (thanks for using a similar color scale) especially when comparing to the relevant DJF season of MAC. However, it looks like that AOD > AODf +AODc why? Your AAOD seems rather low (compared to MAC). And retrievals over NH land (probably due to snow cover) are largely missing so having a complete year for evaluation would be more insightful.

Dear reviewer, thanks for your comments. In that figure, the study period is from 2020.03.01 to 2020.03.20, instead of DJF (do this mean December, January, and February?). In the GRASP, the AOD = AODf + AODc. The reason why AOD is looks like > AODf + AODc may be that we are not using a continuous color scale. As mentioned above, since the GRASP/Models results in a higher SSA, it can be expected that the AAOD will be much lower. This is indeed a problem, but the spatial distribution of AAOD is in line with the trend.
We removed data from high latitudes (> 60) for higher calculation speed and the usage of these data is not high as you said they are affected by snow cover. Yes, for a more insightful assessment, we also plan/want to use a complete year of data in future studies.

Do not work with research algorithms from MISR, these are just as the name said short lived usually with limited coverage better work with operational products.

Dear reviewer, thanks for your suggestions. Yes, we are only interested in the problems about MISR products revealed by this MISR research algorithm.

I like to bias presentation of the bias distribution for the different AOD ranges.

Dear reviewer, thanks for your comments. Yes, we display the bias distribution of different between DPC/GRASPs and MODIS products as shown in Figure 7.

Round 2：Respond to Reviewer #3

Dear reviewer, thanks for your comments. We have carefully read your comments, and replied to your comments point by point with corresponding modifications in the manuscript. It is no doubt that your comments are very important to us. In the following, your comments are marked in bold italics, our responses are in black, and the modifications in manuscript are shown in blue.

I thank the authors for their revisions to the manuscript, which I feel improved it sufficiently to warrant publication. I am particularly pleased with the additional figures. I have a few comments on the reply for the author's to consider in future,
- In your reply to Reviewer 2 about L251, you say that "It should be noted that the contributiuon of the super large particles is accounted in those bins", referring to the five lognormal bins of GRASP. While you are correct that the existing bin scheme provides very large particles from the tails of those distributions, this will be correlated to the loading of small particles (i.e. to get lots of large particles requires also having more 2.9um particles). Coarse and fine mode aerosols have different sources and sinks, such that an ideal bin model would have a separate mode for the coarse mode that can be adjusted independently.

Thank you for these suggestions. In the current version of GRASP, it hopes to retrieve aerosols with a consistent assumption and constraints in the global. Therefore, a specific aerosol type which only appear in a unique environment have not been considered. Of course, region-specific optimizations should not be excluded either, and we will continue to consider this issue in future research.

- I am intrigued by your finding that MISR systematically underestimates AOD, as my experience with the v23 data has been quite good. This may simply be a cultural difference, but if I'd found a problem in someone else's data, that comparison would have been front-and-centre in my paper. Finally, it should be noted that the MODIS products are not perfect and differing from MODIS does not necessarily mean one is wrong. For example, there is an ongoing discussion about the AOD of remote, clean air.

Thank you for your comments. Yes, in China, we are more concerned with high aerosol loading conditions because air pollution is still a big problem. Under the low aerosol loading conditions, the performance of MISR is very well.

- My sincere apologies for misrepresenting your relationship to Li et al. 2022. I did try to check the affiliations, but it can be difficult from Europe to search for details of researchers at Chinese institutions.

Thank you for the understanding and recognition!

- When I asked for a comparison to another implementation of GRASP, I wasn't thinking of different GRASP versions applied to DPC. I was thinking of comparison to existing products processed with GRASP, such as POLDER (https://www.grasp-open.com/products/polder-data-release/). By using an existing algorithm like GRASP, your team is well positioned to untangle the errors caused by the algorithm and the errors caused by the instrument.

Thank you for your comments. Yes, I agree with you, but the problem is that DPC was launched in 2017, whereas, the POLDER-3 have stopped working after 2013.

- I wish you the best in dealing with the negative drift of DPC. It sounds challenging.

Thank you for your wishes! We will continue to work on the availability of Chinese satellite data.

- To be less flippant, I should explain that Levels 1.5 and 2.0 of AERONET are different filterings of the same underlying data, with the latter being more stringent in the removal of possible cloud contamination and applying more nuanced calibration methods. Using both was "foolish" because the dataset would contain duplicate observations. Apologies if this was not clear from AERONET's documentation.

Thank you for your comments. Yes, we understand this deeply and have made revisions.

- At the end of section 3.2, you filter out "obvious noise" with DOLP > 1. There may be value in evaluating how this filtering biases your products. While it is true that DOLP > 1 is physically impossible, it can be a valid observations when working with noisy radiances from separate sensors. For example, the co-polar channel could experience an unusually negative random fluctuation, pushing that signal below its dark current, at the same time as the cross-polar one experiences an unusually positive one. An equivalent problem occurs in lidar analysis, where it was found that removing unphysical observations introduced a positive bias into the final products as the filtering had artificially truncated the otherwise symmetrical distribution of random errors.

Thank you for your comments and experience, it taught me a lot. However, as far as I know, the case of DOLP>1 cannot input and handle in a general forward model. In the future, we will consider and deal with such issues more carefully.

Some further technical corrections, using line numbers from the document with tracked changes:
Figs.2-4) There are horizontal dashed lines at semi-random levels (i.e. at 0.5 and 0.75 in 2(c) but at -0.75, -0.5, 0, 0.75 in Fig.4(c). There's nothing wrong with having a grid but try to be consistent between plots.

Thank you for your comments. This is mainly caused by the compression of pictures in the word software, and now we have fixed this problem.

Below we show the specific language modifications:

L25) coverage is ~2 days

The spatial resolution is ~ 3.3 km at nadir and glob**al coverage is ~~in~~ ~2 days.**

L35) From most AERONET sites

From the most ~~**of**~~ AERONET sites, the R and EE% were larger than ~0.9 and ~80%.

L40) ability of the DPC

The above findings validated the ability of **the** DPC sensor to monitor aerosols.

L92) with a relatively high spatial resolution

with **a** relatively **higher** ~~**r**~~ spatial resolution of 3.3 km, that can observe Earth from ~9 different angles.

L97) There is a space before the period here.

The multi-angular polarized sensor can provide many more observations for the same pixel in an aerosol parameter **retrieval.**

L102) the surface accounts

A well-known advantage is that the polarized light from the surface ~~**is**~~ accounts for a small part of the total polarized light

L132) Capitalise Earth.

that can observe ~~**earth**~~ Earth from ~9 different angles in a local time of ~13:30 PM

L147) valuable Earth observations

The Moderate-resolution Imaging Spectroradiometer (MODIS) has been in service for over two decades, providing valuable Earth~~**'s**~~ observations.

L173) to average satellite data

a common approach is followed to average~~**s**~~ satellite data within ±30 min and a circle of 0.25° (~25 km) radius

L191) in the construction of the modelled reflectance

surface properties (Bidirectional Reflectance/Polarization Distribution Function, BR/PDF, etc.) **in the construction of the modelled reflectance**.

L212) the [I,Q,U]^T represent

where, the $[I, Q, U]^T$ ~~**are**~~ represent the radiative and polarized radiances

L219-20) "Cloudy pixels are the main factor" or "Cloud contaimination is the main factor"

Cloudy pixels are the main factor impacting aerosol retrieval, because they will block the signal from aerosol due to high reflectance, large coverage, and relatively high vertical position

L247) to generate a cloud mask

This feature has been used to **a** generate cloud mask product for both POLDER and DPC sensors

L271) For instance, the GRASP

For instance~~**s**~~, the GRASP software gives two retrieval schemes for POLDER observations.

L280-1) "The GRASP/Models approach assumes an external mixture of several" or "The GRASP/Models approach assumes externally mixed aerosols, which"

The GRASP/Models approach assumes **an external mixture of several aerosol types** with fixed optical parameters

L298) using the Lagrange multiplier

Spatial and temporal constraints of variabilities of aerosol and surface properties are realized ~~**by**~~ using Lagrange multiplier method.

L317) probably underestimates the AOD

This means that under heavy aerosol loading, the DPC/GRASP probably underestimate**s** the AOD.

L346) Delete "While" as this statement doesn't preceed a sentence.

~~**While,**~~ **The** absolute MB had a trend to decrease first and then increase, with increase in the polarized fitting residuals.

L362) You say, "Figure 4b displayed the changes." Usually, one refers to things with a document in the present tense (e.g. "displays the changes"). You aren't strictly wrong here - the figures did show those things in the past - but it sounds weird. This also occurs at L436, 475.

Figure 4c displayeds the changes of differences between DPC and AEROENT AOD.
Figure 7 showeds density distributions of difference between DPC and MODIS products in ranges of AOD
Figure 9 showeds three cases at different underlying surface to display the time series of AOD retrieved from DPC GRASP/Models on the basis of AERONET observations

L379) while the lower values

The high values of R (> 0.8) were found in most regions, while the ~~**several**~~ lower values (~0.6) were mainly observed in North America.

L385) in most areas

From the MB of **Figure 5c**, the values of AOD were overestimated (~0.04) in ~~**the**~~ most areas.

L404) resulted in the underestimation

This also partially resulted **in** the underestimation of DPC AOD because the heavy aerosol loading pixels are removed.

L411) This phenonmenon is caused by unsuitable aerosol models, which further results in a persistent overestimation in the DT algorithm

This phenomenon is caused by unsuitable aerosol models, which further results in a persistent overestimation in the DT algorithm

L418-9) loading is low most of the year

Another case was selected in Western Europe where the air is clean and aerosol loading is low (< 0.2) ~~**in the most if time around year**~~ most of the year.

L438-9) regions. A common pattern is seen in all sub-plots

~~**It can be found**~~ A common pattern ~~**showed**~~ is seen in all sub-plots, namely that the differences were nearly normally distributed

L439) Either put "and" or a comma after "distributed".

namely that the differences were nearly normally distributed**,** centered on the 0 under low aerosol

loading conditions (AOD ⩽ 0.2).

L454) period to avoid how global validation statistics shift with the spatial distribution of observations

The AERONET stations had relatively continuous observations during the study **period to avoid how global validation statistics shift with the spatial distribution of observations**

L489) "The main purpose was to evaluate" to be consistent with the tense of the previous sentence. Also, in the conclusions we're talking about things that have been done rather than things that are happening now so the past tense is appropriate.

The main purpose **was** to evaluate the performance of the DPC to monitor global aerosols.

L506) respectively at most AERONET sites

In the perspective of spatial scale, the R and EE% of GRASP/Models were larger than 0.9 and 80% respectively at ~~**the**~~ most AERONET sites.

L512) overstrict cloud masking

However, the values of AOD were underestimated by DPC, probably due to overstrict cloud **masking**

L515-6) The study improves our understanding of DPC and finds a solution

The study improves to our understanding of DPC and finds a solution for retrieving AOD based on GRASP algorithm.

L676) The page number for Lui 2022 is 106121.

Liu, B., Ma, X., Ma, Y., Li, H., Jin, S., Fan, R., & Gong, W. (2022). The relationship between atmospheric boundary layer and temperature inversion layer and their aerosol capture capabilities. Atmospheric Research, 271, **106121**, doi:10.1016/j.atmosres.2022.106121

L688) The page number for Martins 2002 is MOD4 (GRL had a period of weird numbering.)

Martins, J.V., Tanré, D., Remer, L., Kaufman, Y., Mattoo, S., & Levy, R. (2002). MODIS Cloud screening for remote sensing of aerosols over oceans using spatial variability. Geophysical Research Letters, 29, **MOD4**, doi:10.1029/2001GL013252