Report 3

Reply to Anonymous Referee #4

General comments:

This manuscript presents the simultaneous retrieval of aerosol optical depth (AOD), single scattering albedo (SSA) and directional-hemispheric reflectance (DHR) from the Directional Polarimetric Camera (DPC) aboard China's Gaofen-5 satellite. The sensitivity analysis, performance evaluation by synthetic data, and application to actual DPC data are discussed. The sensitivity analysis demonstrates the challenges in retrieving SSA values from the DPC data, while the algorithm based on optimal estimation is designed to overcome the challenges. The performance of the developed algorithm is evaluated both based on synthetic data and Aerosol Robotic Network (AERONET) data. A case study and global maps are also presented. While this manuscript covers a very challenging topic and takes a conservative approach, the restrained reproducibility and incomplete analysis limit the value of this manuscript to the research community. The manuscript would require a substantial revision for final publication in AMT if authors are willing to do so. The following points should be addressed to increase the impact of this manuscript.

We appreciate the reviewer for the constructive comments and thoughtful suggestions, which are very helpful in improving our manuscript. We have carefully considered all the comments and revised the manuscript accordingly. Below is a detailed point-by-point response to these comments.

1. Identifying the original dataset. This study uses DPC, MODIS, ERA5, HYCOM and AERONET data. However, some descriptions are missing regarding product type, time period (start date and end date), dataset size (number of pixels and number of AERONET sites). Please detail as much as possible, and if not sufficient, use Appendix to describe the data so that readers can collect necessary data.

Thanks for the suggestion. The temporal coverage of this study is primarily constrained by the availability of DPC observations. Specifically, we have six months of DPC data,

encompassing April, July, and October 2019, as well as January–March 2020. The MODIS, ERA5, HYCOM, and AERONET teams provide continuous data covering this period, enabling the retrieval and validation in this study. We have added this information in the manuscript in L75-77:

> *Six months of DPC Level 1 data, encompassing April, July, and October 2019, as well as January-March 2020, are used in the retrieval in this study. The AERONET, MODIS, as well as other auxiliary data are selected from the same periods.*

The temporal and spatial resolution of the auxiliary data are described in Sect. 2.2 in the manuscript. We have summarized them in Table 1 in the manuscript.

2. Describing applied corrections and filters. It appears that authors have applied some corrections to DPC data, but the details are not presented. Some references are provided, but it would be beneficial to briefly describe the outline of the applied corrections. In addition, the "fine-mode filtering" of AERONET data (and potentially retrieval results) remains unclear. Documenting the number of points (pixels) before and after filtering would help readers understand the extent of filtering.

Thanks for the suggestion. Following the launch of DPC, gradual aging of its optical components led to a drift in radiometric response, with the magnitude of the drift related to both time and VZA. Zhu et al. (2022) calibrated this drift using DPC observations over deep ocean regions through the Rayleigh method and provided monthly VZA-dependent calibration coefficients. In this study, DPC observations were corrected using these calibration coefficients to reduce radiometric biases as much as possible. We have added details about the calibration in the manuscript in L82-89:

> *The radiometric response of DPC/GaoFen-5 is progressively drifting over time and is realted to VZA. Zhu et al. (2022) developed a method based on Rayleigh scattering over the ocean to correct this drift. In deep ocean regions with very low aerosol loading and low surface reflectance, the TOA radiance observed by satellite sensors is dominated by atmospheric Rayleigh scattering, which can be accurately simulated using radiative transfer models. By comparing simulated*

radiances with DPC observations over such regions, Zhu et al. (2022) provided monthly VZA-dependent calibration coefficients at 443, 490, 565, and 670 nm. The calibration uncertainties are about 1-7 % (depending on the wavelength and VZA). In this study, these Rayleigh scattering-based calibration coefficients are applied to correct DPC's scalar reflectance at 443, 490, 565, and 670 nm.

In this study, only the official AERONET Level 2.0 quality control criteria (excluding the AOD threshold) were applied to the Level 1.5 inversion data to ensure the accuracy of AERONET SSA. No additional screening was applied to AERONET observations. However, quality control was performed on the retrieval results, based on whether the retrieved parameters exceeded predefined thresholds. Retrievals yielding physically unreasonable values outside these thresholds were regarded as failed cases and were excluded from further analysis. The predefined thresholds have been summarized in Table 3 in the manuscript.

3. Clarifying the measurement vector, a priori state vector, model parameters, and variance-covariance matrix in the retrieval algorithm. The developed algorithm is based on optimal estimation. Optimal estimation is a blending of measurements and a priori information based on variance, and therefore the information on the a priori state vector, model parameters, and variance-covariance matrices should be documented and the reasons behind the choice should be described. This shortcoming makes the study non-reproducible and the interpretation of results very challenging. In addition, the measurement vector elements remain ambiguous. It is requested to document the used spectral channel, polarization or not, and the filtering applied to the input data.

Thanks for this important suggestion. We agree that a clear and complete description of the measurement vector, the a priori state vector, the model parameters, and the associated variance-covariance matrices is essential. In the revised manuscript, we have expanded the description of the retrieval algorithm, and added two tables (Tables 2 and 3) to summarize these settings. Specifically, Table 2 summarizes the selected DPC measurements and their associated uncertainty specifications, while Table 3 lists the prescribed a priori values and uncertainties for aerosol and surface parameters.

In particular, we have clarified the composition of the measurement vector **y**, including the spectral channels, the use of polarization information, and the angular sampling strategy, in L167-173:

> *The measurement vector, $\boldsymbol{y}$, is constructed with calibrated scalar reflectance at 443, 490, 565, and 670, as well as DOLP at 490 and 670 nm from several angles…Pixels with fewer than 9 viewing angles, which are primarily located near the scan edges, were therefore excluded. For the remaining pixels, observations from the first 9 viewing angles were used in the retrieval to maintain a fixed number of viewing angles for all pixels.*

The measurement error covariance matrix is calculated based on DPC calibration uncertainties, which has also been specified in L176-178:

> *Therefore, this study adopts the official pre-launch laboratory calibration errors, namely 5 % radiance errors and 0.02 DOLP errors (Li et al., 2018), as the observational errors used to construct the measurement error covariance matrix.*

In addition, the retrieval parameters composing the state vector **x** and the model parameterization used over land and water have been made explicit in L180-189:

> *The state vector, $\boldsymbol{x}$, is composed of aerosol and surface parameters. Particularly, for land surfaces, the state vector $\boldsymbol{x}$ consists of AOD ($\tau(\lambda)$), SSA ($\omega(\lambda)$), kernel intensity parameters of RTLS model ($K(\lambda)$, k_{vol}, and k_{geo} in Eq. 2), and the scale factor of BPDF-NDVI model (C in Eq. 8)…For water surfaces, only $\tau(\lambda)$ and $\omega(\lambda)$ are retrieved as components of the state vector $\boldsymbol{x}$, and the New Cox-Munk model is implemented to compute the surface reflectance (Spurr, 2006). The wavelength-dependent parameters, $\tau(\lambda)$, $\omega(\lambda)$, and $K(\lambda)$, are retrieved at 443, 490, 565, and 670 nm, corresponding to the wavelengths at which DPC observations are used to construct the measurement vector.*

The description of a priori values and the corresponding uncertainties has been clarified in L189-192:

For AOD and SSA, the a priori state vector and its associated error covariance matrix are prescribed as fixed values, derived from the mean and variance of AERONET measurements. The a priori estimates of surface properties are also fixed, with their errors defined by the corresponding ranges of variability.

Finally, we have stated that the cost function minimization is implemented through an iterative Gauss–Newton approach (L201):

The algorithm minimizes the cost function defined in Eq. 4 using an iterative Gauss–Newton method to obtain the final retrieval results.

We believe these revisions address the reviewer's concerns by documenting the measurement vector elements, the state vector and model parameterization, and the variance-covariance assumptions and a priori settings, with configurations listed in Tables 2 and 3.

4. Improving the compatibility with other studies. The validation sections discuss mainly the results at 443 nm, but a number of previous research use 550 nm for comparison. The contribution of fine-mode particles is substantially different between two wavelengths and presented results are not directly comparable. Even if the results at 550 nm may not be very encouraging, it serves the community to understand what to improve in the next instrument and algorithm development.

Thanks for the suggestion. The retrieval results of this study are primarily validated against AERONET observations, which provide high-quality aerosol measurements and are widely used as a reference dataset. Particularly, AERONET inversion products are available at 440, 675, 870, and 1020 nm, thus an important consideration for focusing on the 440 nm results is the direct availability of AERONET observations at this wavelength. In the revised manuscript, we have added results at additional wavelengths and included comparisons with other studies.

Other satellite products, such as the widely used MODIS AOD, mainly provide retrievals at 550 nm and are commonly applied in large-scale or spatial pattern analysis. Accordingly,

maps of the retrieval results at 550 nm have been included in the Supplement and compared with MODIS AOD.

5. Deepening the analysis of the case study and global statistics. Although authors mention in the conclusions that the analysis remains qualitative, there are unexplained patterns and characteristics in the case study and the global map. Figure 9 seems to be influenced by the number of view directions (bands-like patterns running in satellite cross-track direction) and Figures 10 and 11 show the difficulties probably related to cloud mask (Southern Ocean AOT values) and view geometry (sharp contrast of SSA that stretches along the orbit).

We thank the reviewer for the helpful comment.

(1) In this study, the number of viewing angles used in the retrieval are fixed. We screened pixels with fewer than 9 viewing angles, and only use observations from the first 9 viewing angles for the remaining pixels. We have added this detail in the manuscript in L171-173:

Pixels with fewer than 9 viewing angles, which are primarily located near the scan edges, were therefore excluded. For the remaining pixels, observations from the first 9 viewing angles were used in the retrieval to maintain a fixed number of viewing angles for all pixels.

Therefore, the band-like patterns in Figure 9 are probably not caused by the number multi-angle observation itself. Instead, they might be related to variations in viewing-angle distribution between successive cross-track scans of DPC.

As mentioned in the revised manuscript in L79:

However, after launch, DPC exhibited a gradual change in radiometric sensitivity, primarily due to aging of the optical components. This drift is dependent on both wavelength and field of view and can introduce increasing systematic biases if not properly corrected.

Due to aging of the DPC optical components, the radiometric response experienced VZA-dependent drift. When the satellite switches from one cross-track scan to the next, the

distribution of viewing angles changes sharply. As a result, the magnitude of radiometric drift may differ between adjacent scans. Although radiometric calibration is applied before the retrieval process, this correction cannot completely remove the VZA-dependent residual errors. These residual differences may lead to meridional discontinuities in the retrieval results.

We have revised the manuscript in L389-396 to clarify this explanation:

> *The meridional discontinuities in Fig. 9(b,c) primarily originate from abrupt changes in the observed radiance between successive cross-track scans of DPC, rather than from the retrieval algorithm itself. These discontinuities arise when the instrument switches from one cross-track scan to the next, during which the distribution of viewing angle changes. Due to aging of the DPC optical components, the radiometric response exhibits VZA-dependent drifts. Consequently, variations in viewing-angle distribution lead to variations in the magnitude of this drift, leading to radiance inconsistencies between adjacent scans. Although radiometric calibration is applied prior to the retrieval, the VZA-dependent residual errors cannot be completely eliminated. These residual radiometric differences ultimately result in the meridional striping patterns seen in the retrieval results.*

(2) As for the abnormally high AOD values observed over the Southern Ocean in Fig. 10, we conducted further examinations using true-color imagery and MODIS AOD products. The true-color imagery for early January 2020 reveals extensive smoke plumes over the Southern Ocean originating from southeastern Australia and gradually transported eastward. This indicates that large amounts of biomass-burning aerosols were present over the region during this period. The MODIS monthly AOD product for January 2020 also shows anomalously high AOD over the Southern Ocean, with values exceeding 0.5 in some areas (Fig. R3-1). The spatial pattern and magnitude are generally consistent with our retrieval results. Thus, this magnitude is likely reasonable. We have added the corresponding MODIS AOD map to the Supplement material, and included a relevant discussion in the manuscript in L440-442:

The anomalously high AOD over the Southern Ocean in January 2020 reaches values of up to 0.5 in some regions, consistent with independent data sources (e.g., MODIS AOD, see Supplement).

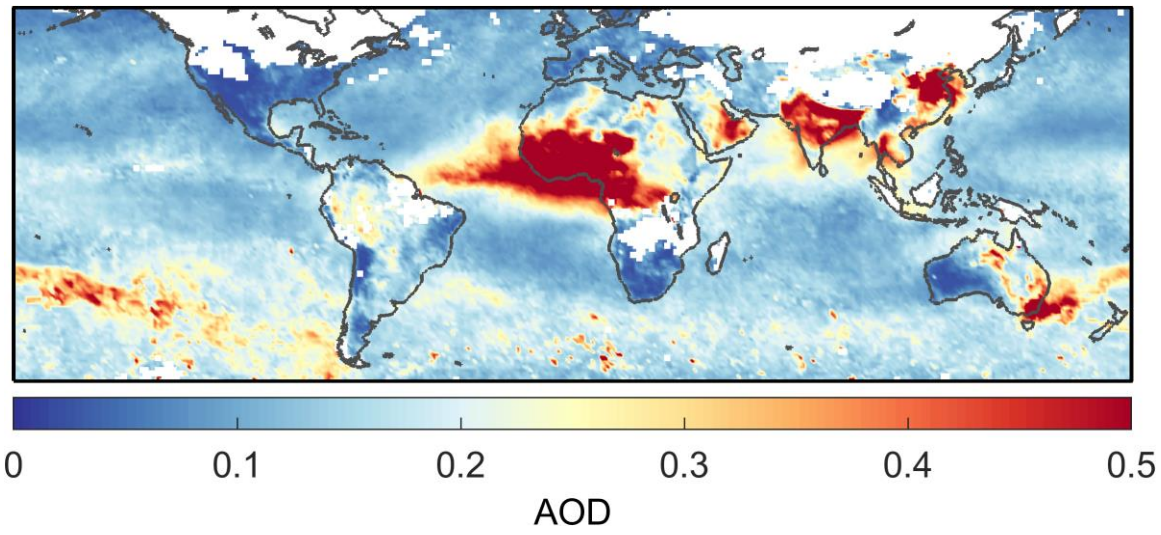

Fig. R3-1. Global AOD for January 2020 at 550 nm from MODIS/Aqua Level 3 product.

(3) We agree that the sharp zonal contrast of SSA along the orbit is closely related to viewing geometry effects. In the revised analysis, we further examined the impact of ocean glint geometry. When the glint angle is small (≤ 40°), enhanced surface reflection over ocean increases the sensitivity of the retrieval to geometry-related biases. After excluding oceanic pixels with glint angle ≤ 40°, the sharp contrast of SSA along the orbit is substantially reduced, and the spatial continuity of the retrievals is significantly improved. This improvement confirms that the previously observed discontinuities are indeed strongly associated with viewing geometry effects. We have updated the global maps, removed the previous statements regarding zonal discontinuities, and added a detailed description of the pixel-screening procedure in the revised manuscript in L198:

Pixels with glint angle ≤ 40° over ocean are also excluded, because enhanced specular reflection at small glint angles reduces the aerosol information content and may introduce geometry-dependent artifacts.

Specific comments:

1. Line 44: It is somewhat misleading to claim that DPC follows up the data gap after the retirement of the POLDER sensors because there are no Chinese investments in international public data dissemination to my knowledge. If there is any news about this, please comment or refer to an article. This is important for the European community that is the main target of this journal.

Thanks for reminding. We have revised the expression in the manuscript in L41:

> *After the retirement of POLDER in 2013, operational spaceborne multi-angle polarimetric observations became limited. The launch of the Directional Polarimetric Camera (DPC) onboard Gaofen-5 in 2018 introduced a new source of multi-angle polarimetric measurements. These observations have supported developments in SSA retrievals in recent years.*

2. Line 76: "theoretical correction errors". This expression is confusing. Is this the magnitude of correction, or the remaining bias after applying the correction? Please clarify.

We are sorry for the confusion. What we intend to convey is that this uncertainty originates from the calibration method itself, which are related to uncertainties of input parameters. We have revised the expression in the manuscript in L87:

> *The uncertainty associated with the calibration method is about 1-7 % (depending on the wavelength and VZA).*

3. Lines 84-86: "Considering relatively …". Two referenced papers are not providing the ground to use a single aerosol model to analyze polarimetric measurements. Both studies focused on MODIS retrievals.

We are sorry for the confusion. We agree that the two cited studies focused on MODIS scalar retrievals and therefore do not directly justify the use of a single aerosol model for polarimetric measurements. In both studies, sensitivity experiments were conducted by employing different aerosol models, and the results indicated that retrieval errors induced by the phase matrix were smaller than those associated with AOD, SSA, and surface albedo.

However, these analyses were based on single-angle scalar observations rather than polarization measurements. To address this concern more rigorously in the present study, we have added additional sensitivity experiments to explicitly evaluate the impact of the aerosol phase matrix within our retrieval framework. The results confirm that, although some variability is introduced by different phase matrices, the induced uncertainties remain smaller than those associated with other parameters. The corresponding analyses and discussions have been incorporated into the revised manuscript in Sect. 3.1 to provide a more solid justification for the adopted aerosol model configuration.

4. Lines 121-122: "accurately", "high-precision". The relevance to this paper is the accuracy and precision needed for this research. Unless there are strict requirements that limits the choice of radiative transfer models, I suggest removing these non-quantitative expressions.

We thank the reviewer for the suggestion. We agree that the terms "accurately" and "high-precision" are qualitative and not strictly quantified in this context. Since this study does not impose explicit accuracy or precision constraints that would limit the choice of radiative transfer models, these expressions have been removed to avoid overstatement. We have revised the expression in L135-137 to focus on the functional capabilities of the model rather than qualitative performance descriptions:

> *It simulates Stokes vectors and their linearized matrices (Jacobians) at arbitrary altitudes and viewing geometries, providing radiative simulations for satellite remote sensing applications and serving as an effective forward model in numerical inversion algorithms (Spurr, 2006).*

5. Line 157: "fixed constants". Optimal estimation is a blending of a priori and measurements, and therefore the assumption used in the a priori can easily bias the estimation when the measurement information content is not sufficient. The precise values used in this study should be presented with reasons of choice.

We thank the reviewer for the insightful comment. We agree that, in general, the choice of a priori assumptions in optimal estimation may influence the retrieval when the measurement information content is limited. In this study, however, the focus is on

evaluating the robustness and reliability of the retrieval algorithm itself under a controlled and simplified configuration. Therefore, fixed a priori values and associated errors are adopted to ensure consistency and reproducibility of the results. The a priori values and associated errors for AOD and SSA are derived from the mean and standard deviation of AERONET observations, providing physically reasonable and observationally based constraints. The a priori estimates of surface properties are also prescribed as fixed values, with their associated uncertainties defined according to the corresponding ranges of variability. These a priori values and associated errors have been documented in Table 3 in the manuscript, and a corresponding description has been added in L189-194:

> *For AOD and SSA, the a priori state vector and its associated error covariance matrix are prescribed as fixed values, derived from the mean and variance of AERONET measurements. The a priori estimates of surface properties are also fixed, with their errors defined by the corresponding ranges of variability. The use of fixed a priori values is intended to provide a controlled and consistent configuration for evaluating the inherent performance of the retrieval algorithm. Details of the a priori values and associated errors are summarized in Table 3.*

6. Line 211: This section presents the results of numerical simulation, but the simulation geometry is not mentioned anywhere, limiting the reproducibility of the obtained results.

We thank the reviewer for pointing out this missing description. We agree that a clear description of the simulation geometry is essential for the reproducibility of the sensitivity experiments. In the revised manuscript, we have listed the SZA, VZA, and RAA in Table 4 used in the simulations. We have also added details in the manuscript in L216:

> *The simulations were conducted under a series of SZA, VZA, and RAA, as listed in Table 4.*

7. Lines 215-216: “not sensitive”. This sentence is an overstatement as only one aerosol model and two land surface models are employed. It also contradicts to the previous studies, notably to the study of critical surface albedo by Seidel and Popp (2012).

We thank the reviewer for this important comment. We agree that the term "not sensitive" was inappropriate and could be misleading in this context. The intended meaning of the original statement was not that the magnitude of the response is insensitive to surface parameters, but rather that, for the two land surface models considered, the response patterns of ΔI and ΔDOLP to prescribed SSA perturbations are similar. We have revised the text accordingly to emphasize the similarity in the overall trends, while explicitly acknowledging the presence of differences in magnitude and angular distribution. We have revised the expression in the manuscript in L253-255:

> *Despite minor differences in magnitude and angular distribution, the changes in I and DOLP induced by the prescribed SSA perturbations exhibit similar overall patterns for the two land surface models considered.*

The revised expression avoids overgeneralization and does not imply a general insensitivity to surface properties.

8. Figure 2, 3, and 4: Fluctuating results from the radiative transfer simulation of such smooth phase function is surprising. Are small fluctuations of these curves significant? What is the precision of the radiative transfer simulation in this study? Adding error bound and explanation in the main text deems necessary.

Thank you for this constructive comment. The scattering angle is calculated from various combinations of SZA, VZA, and RAA, which are grouped into bins and are now listed in Table 4 in the revised manuscript. For similar scattering angles, the corresponding SZA-VZA-RAA combinations may differ substantially. Such differences may lead to distinct atmospheric photon path lengths in the radiative transfer calculations. In addition, the surface reflectance is also anisotropic, which may also attribute to variations in simulated TOA radiance. To further clarify this issue, we have provided the error bounds in the updated figures. The error bounds are now explicitly reported in the manuscript.

9. Line 251: In this section (Section 3.2) and in the following section (Section 3.3), I consider that it is necessary to perform the performance comparison at 550 nm (or 565 nm) rather than at 443 nm. Otherwise, this manuscript is not comparable to other previous publications that authors themselves referenced. As authors mention

near Line 285, the retrieval performance depends on wavelength and available information. This is why the comparison at an inconsistent wavelength is not adequate.

We thank the reviewer for this important comment. In the revised manuscript, we have added the corresponding analysis at 565 nm in Sects. 3.2 and 3.3. This ensures better comparability with prior publications and provides a more appropriate evaluation of the retrieval performance across wavelengths.

10. Line 254: "443 nm AOD". This has to be kept as AOT at 443 nm, even when comparing the performance of AOT and SSA at 550 nm, in order to be consistent with AERONET processing algorithm that applies the "fine mode filter" by AOT 440 nm.

We thank the reviewer for pointing it out. We have revised the text to explicitly state that the fine-mode filtering is consistently based on AOD at 443 nm, in line with the AERONET processing algorithm that applies the filter at 440 nm. This AOD (443 nm) threshold is used solely as a selection criterion for SSA validation and is applied uniformly throughout the analysis, independent of the wavelength at which AOD or SSA performance is evaluated. The expression in the manuscript has been revised in L295-298:

For this reason, the validation applied an AOD-based screening criterion using AOD_{443} *(AOD at 443 nm). Only SSA retrievals with* $AOD_{443} > 0.4$ *were retained, consistent with the AERONET fine-mode filtering criterion. This criterion was applied uniformly throughout the analysis, independent of the wavelength at which AOD or SSA was evaluated.*

11. Line 288: Same comment as Line 251 for this section.

Thanks for the comment. As mentioned above, analysis at 565 nm has also been added in Sect. 3.3.

12. Line 292: "similar performance". This reads contradictory to Line 266, "relatively weaker performance". The correlation coefficient of SSA drops from 0.688 at 443

nm to 0.347 at 565 nm, and it is difficult to claim that the performance at 565 nm is "similar" to that at 443 nm.

We are sorry for the confusion. We agree that the phrase "similar performance" was inappropriate and could be misleading, given the clear degradation in SSA retrieval performance from 443 nm to 565 nm. The intended meaning was that the wavelength dependence of the retrieval performance, namely the decreasing performance with increasing wavelength, is consistent with the behavior observed in the simulated-data experiments. However, in the revised manuscript, we have updated the retrieval experiment, and the expression about "similar performance" has been removed.

13. Line 299: "comparable to the operational MODIS AOD product (Levy et al., 2010)". This claim is an overstatement. The referenced paper reports the correlation coefficient of 0.896 for AOT at 470 nm and 0.882 for AOT at 550 nm. This sentence claims that correlation coefficient of 0.75 for AOT at 443 nm is comparable.

We thank the reviewer for this comment. We agree that the correlation coefficient of 0.75 obtained in this study is lower than those reported for the operational MODIS AOD product in Levy et al. (2010), and the original expression was therefore an overstatement. The text has been revised in L334-336 to acknowledge that the performance is weaker than that of the operational MODIS product, while still indicating that the retrieved AOD shows a reasonable level of consistency with AERONET observations:

This performance is slightly lower than that reported for the operational MODIS AOD products (Levy et al., 2010), but it is comparable in terms of AOD correlation to the DPC retrievals reported by Dong et al. (2024), who obtained a correlation coefficient of 0.76 for AOD at 670 nm.

14. Line 339: "strong absorption properties". In Levy et al. 2007a, heavy smoke by biomass burning is recommended to be modeled by their "absorbing" model, instead of "moderately absorbing" model, while this study uses their "moderately absorbing" model and employ the heavy smoke case as a case study. It is worth mentioning the reasons behind the inconsistency.

Thank you for this insightful comment. To address this concern, we conducted additional sensitivity experiments in Sect. 3.1 to quantify the impact of using different phase matrices on the retrieval results. We also present the results in Fig. R3-2. The analysis shows that the errors introduced by the choice of phase matrix are relatively small. Therefore, the use of the "moderately absorbing" model does not lead to significant biases in the heavy smoke case considered in this study.

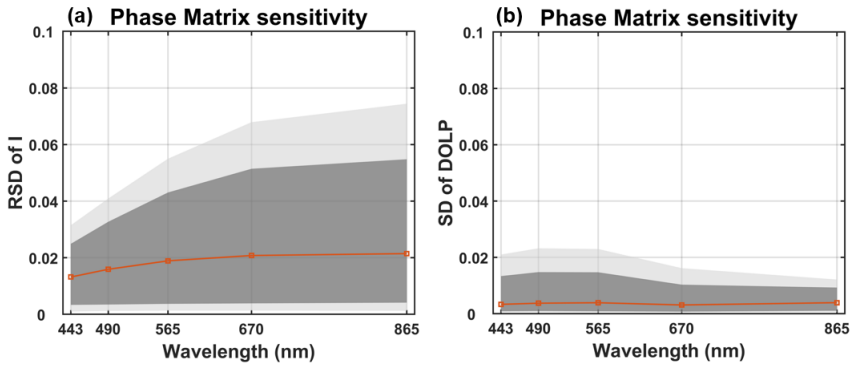

Fig. R3-2. Relative standard deviation (RSD) of I (a) and standard deviation (SD) of DOLP (b) induced by variations in phase matrix.

Technical comments:

1. Line 67: "normalized radiation". normalized radiance

Thanks for reminding. We have revised the expression in the manuscript.

2. Lines 140-141, 145: xa. Using xa as a-posteriori state vector is rather confusing as Sa is used for a-priori variance-covariance matrix. I suggest replacing by x^ (x-hat, circumflex above x) , following the common convention.

Thanks for the suggestion. We have replaced $\mathbf{x}^{\mathbf{a}}$ with $\hat{\mathbf{x}}$ in the manuscript.

Reference

Dong, Y., Li, J., Zhang, Z., Zheng, Y., Zhang, C., & Li, Z. (2024). Machine learning-based retrieval of aerosol and surface properties over land from the gaofen-5 directional polarimetric camera measurements. *IEEE Transactions on Geoscience and Remote Sensing*, *62*, 1–15. https://doi.org/10.1109/tgrs.2024.3419169

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Zhu, S., Li, Z., Qie, L., Xu, H., Ge, B., Xie, Y., et al. (2022). In-flight relative radiometric calibration of a wide field of view directional polarimetric camera based on the rayleigh scattering over ocean. *Remote Sensing*, *14*(5), 1211. https://doi.org/10.3390/rs14051211