We would like to thank the three referees and the editor for their time reviewing the manuscript, and for the helpful feedback provided. The detailed responses to all referees are provided below.

Reviewer #3:

This manuscript developed new aerosol and surface products from the first 18 months multispectral and polarized measurements of POSP/GF-5(02) based on the Generalized Retrieval of Atmosphere and Surface Properties (GRASP)/Models approach. These products are validated and intercompared with ground-based aerosol inversion dataset and other independent satellite aerosol and surface products. The results show generally good consistency of POSP products including not only total Aerosol Optical Depth (AOD), but also detailed aerosol properties such as aerosol size, absorption, layer height, type, etc., as well as full surface Bidirectional Reflectance Distribution Function (BRDF), Bidirectional Polarization Distribution Function (BPDF), black-sky, white-sky albedos and Normalized Difference Vegetation Index (NDVI). This research deserves to being published given the new valuable satellite products development, but there are still some descriptions and statements unclear and need to be improved. The detailed comments can be found below.

Response:

We would like to thank the reviewer for your time reviewing the manuscript and appreciate the constructive comments on our paper.

1. Introduction: I think most parts of the first paragraph needs to be re-written. POSP is a single-viewing multi-spectral polarimetric sensor aimed at aerosol detection, so I suppose this paragraph should introduce the research background about using multispectral or polarized measurements to retrieve aerosol properties. However, the authors mainly

discuss aerosol retrievals from multi-angle polarimetric measurements, while multi-angle is not one of the characteristics of POSP. I suggest to focus on the characteristics of POSP and introduce the underlying fundamental physics here.

Response:

Thanks for the suggestion! We have added some description about the POSP background and its main goal in the introduction. Generally, POSP was designed to enhance the atmospheric aerosol detection capability particularly for aerosol layer height, fine/coarse mode, to achieve the main goal of the GF-5(02) mission that is dedicated for $PM_{2.5}$ remote sensing (Li et al., 2022).

"POSP was designed to complement DPC measurement, which is a multi-angular polarimeter on the same platform with maximum 17 viewing angle and ~3.3 km spatial resolution measuring I, Q, U at VIS-NIR channels. POSP could extend to UV and SWIR channels, which is expected to enhance the atmospheric aerosol detection capability, particularly for aerosol layer height, fine/coarse mode, to achieve the main goal of the GF-5(02) mission that is dedicated for $PM_{2.5}$ remote sensing (Li et al., 2022). Meanwhile due to the on-board calibration device for POSP, it was expected to obtain higher accuracy of intensity/polarization measurements than DPC, which could perform cross-calibration between DPC and POSP (Lei et al., 2023). Therefore, the cross-track pattern was chosen to achieve more overlaps. On the other hand, there is a possibility to request to change POSP's scanning direction from cross-track to along-track.".

Lei, X., Liu, Z., Tao, F., Dong, H., Hou, W., Xiang, G., Qie, L., Meng, B., Li, C., Chen, F., Xie, Y., Zhang, M., Fan, L., Cheng, L., and Hong, J.: Data Comparison and Cross-Calibration between Level 1 Products of DPC and POSP Onboard the Chinese GaoFen-5(02) Satellite, Remote Sensing 2023, Vol. 15, Page 1933, 15, 1933, https://doi.org/10.3390/RS15071933, 2023.

Li, Z., Hou, W., Hong, J., Fan, C., Wei, Y., Liu, Z., Lei, X., Qiao, Y., Hasekamp, O. P., Fu, G., Wang, J., Dubovik, O., Qie, L. L., Zhang, Y., Xu, H., Xie, Y., Song, M., Zou, P., Luo, D., Wang, Y., and Tu, B.: The polarization crossfire (PCF) sensor suite focusing on satellite remote sensing of fine particulate matter PM2.5 from space, J Quant Spectrosc Radiat Transf, 286, 108217, https://doi.org/10.1016/J.JQSRT.2022.108217, 2022.

2. Section 2.1: It is mentioned that ”POSP is the first space-borne multi-spectral crosstrack scanning polarimeter”. Why does POSP use cross-track scanning method instead of along-track scanning? What are the advantages and disadvantages of cross-track scanning? Some background can be added here.

Response:

Thanks! Similar to previous comment, we have added some POSP background and its main goal in the introduction. Specifically, POSP is a cross-track scanning polarimeter flying on the GF-5(02) satellite for the first time. POSP was designed to complement DPC measurement, which is a multi-angular polarimeter on the same platform with maximum 17 viewing angle and ~3.3 km spatial resolution measuring I, Q, U at VIS-NIR channels. POSP could extend to UV and SWIR channels, which is expected to enhance the atmospheric aerosol detection capability, particularly for aerosol layer height, fine/coarse mode, to achieve the main goal of the mission that is dedicated for $PM_{2.5}$ remote sensing (Li et al., 2022). Meanwhile due to the on-board calibration device for POSP, it was expected to obtain higher accuracy of intensity/polarization measurements than DPC, which could perform cross-calibration between DPC and POSP (Lei et al., 2023). Therefore, the cross-track pattern was chosen to achieve more overlaps. On the other hand, there is a possibility to request to change POSP’s scanning direction from cross-track to along-track.

3. Table 1: What is POSP/GF5 overpass time? I suggest to add it in this table and compare it with NOAA-20 since the difference of their overpass time can cause inconsistency in aerosol retrievals as mentioned in the analysis later.

Response:

Thanks! GF-5(02) satellite is in the descending node during the daytime and equatorial crossing time is 10:30 local time. We have added this information to Table 1.

4. Line 203-221: Although these land/ocean surface models including BRDF and BPDF have been discussed in many previous studies, I think some statements are still needed to clarify the meaning of related parameters involved in the state vector, such as aiso, avol and ageom (I assume they are the linear coefficients of three kernels in Ross-Li BRDF model), as well as r0, δFr and σ2. Is BPDF only considered for land surface but not ocean?

Response:

Yes, they are the linear coefficients of three Ross-Li BRDF kernels and BPDF is only considered over land. It's included in the main text in Section 3.1. We have included the descriptions below the list of state vectors. Thanks for the suggestion!

5. Figure 4: It seems the AE and scale height retrieval are less than other parameters, shown as many blank pixels over ocean in (e) and (f). What are the reasons for this situation? Are there any different criteria applied for different parameters retrieval availability or quality?

Response:

For extended aerosol parameters (SSA, AE and Scale Height), we use only POSP AOD (550 nm)>0.2 on daily basis to select high quality retrievals and then obtain the mean

values. Because the retrieval accuracy of these detailed parameters is strongly depending on the aerosol information content, simplistically aerosol loading/AOD. Based on our previous validation activities, satellite AOD higher than 0.2 is one of reasonable criteria to have a direct selection for SSA, AE and Scale Height. We have added this information to the Figure captions.

6. In the scatter plots, such as Figure 6-10, what does the color of each dot mean? This should be added in the caption.

Response:

Thanks for the suggestion! We have revised scatter validation to add heat map plots with the color represents the number of valid points in each 0.01x0.01 grid. Meanwhile, we added the validation plot in logarithmic scale for AOD, AODF and AODC.