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Atmospheric Measurement Techniques Discussions

Interactive comment on "Aerosol retrievals from the ACEPOL Campaign" *by* Guangliang Fu et al.

Anonymous Referee #2

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This paper presents aerosol retrievals from polarized measurements of three different airborne instruments in the ACEPOL campaign. The retrieval results are compared with AERONET inversion products and the lidar onboard the same flight, HSRL2 observations. A good agreement of both AOD and aerosol microphysical properties is found among these observations. Furthermore, aerosol retrievals in two special cases with low and high AOD (smoke plume) are shown. I think this is a good study and suggested to be published after some revisions.

General comments

1. When the authors introduce the SRON multimode retrieval algorithm in section 2.1, no aerosol size distribution parameters are included in the state vector. However, in the retrieval results, effective radius of fine and coarse mode particles are shown. Although the calculation of fine and coarse mode effective radius is presented in section 2.2, the retrieved aerosol parameters related to size parameters are not clear.

2. As defined in the manuscript, the χ^2 used to decide retrieval convergence is different for different instruments. For example, for AirMSPI, observed intensities in 8 bands and DoLP in 3 bands are used in the retrieval, while radiance and DoLP at 16 wavelengths for SPEX are used. Although χ^2 is defined as a mean value of total number of measurements, the ratios $\frac{(F_i-y_i)^2}{S^y(i,i)}$ in Eq. 3 for radiance and DoLP may have different scales. Therefore, if different numbers of radiances and DoLP are used even though two instruments have the same total number of measurements, the χ^2 may differ a lot. Does this problem affect the retrieval results between different instruments? Do they use the same threshold ${\chi_{max}}^2$?

3. The retrieval results of 3 different instruments are compared in this manuscript, but only some statistical parameters, such as MAE, bias and STD are presented. Are there any conclusions or suggestions about the measurements (radiance or DoLP) at which wavelengths are combined better for aerosol retrieval? Or are different numbers of multi-angle measurements affect aerosol retrievals a lot? I think more similar common summaries could attract audiences.

4. In the state vector, aerosol column numbers and microphysical properties are included, thus the AOD in the retrieval at different wavelengths are calculated from retrieved column numbers and other parameters. I'm a little confused that why the authors use different wavelengths when compare total AOD and fine and coarse modes AOD (Figure 1 and Figure 3). If the same wavelengths are used, the retrieval performance of fine, coarse mode AOD and total AOD can also be evaluated.

5. The surface reflectance parameters are retrieved simultaneously with aerosol

properties in the algorithm. How is the performance of surface reflectance retrieval in the campaign? Are the accuracies of retrieved aerosol properties related to surface reflectance?

6. The retrieval accuracy of fine and coarse mode AOD depend on the retrieved aerosol microphysical properties. If the dependence of the retrieval bias of τ^f and τ^c on the accuracy of retrieved r_{eff} or refractive index is shown, it will be interesting and beneficial for distinguishing aerosol types.

Specific comments

1. In the introduction part, the third paragraph in page 2 indicates that combining both intensity and polarization measurements at multiple viewing angles is beneficial for aerosol retrieval. However, this paragraph is too short and simple. This is the most important feature of 3 MAPs used in this manuscript to do retrieval. I think more theoretical foundation and how previous studies use these information could be added.
2. The paragraph at page 3 line 6-10 has little relationship with this study. I believe the authors could delete or short this paragraph and combine it with last paragraph.
3. When giving the information of ACEPOL campaign in the introduction, the information about the altitude aircraft flying is suggested to be provided due to the retrieval of ALH, especially at smoke plume case whose ALH is always high.
4. At page 4 line 20, the meaning of k in the equation is not explained.
5. At page 11 line 18-19, the authors present "the MAE gets smaller with increasing wavelengths, which is mainly caused by the fact that AOD value itself decreases

with wavelength". Some other parameters such as mean relative error (MRE) or root mean squire error (RMSE) could remove this effect and are recommended to be compared.

6. The sentences at line 22-23 and line 30-31 in page 11 present the same thing.
7. At page 13 line 1-2, "for low AOD the effect of the surface on the measured radiances is larger than for SPEX airborne" is presented. I'm a little confused why.
8. At page 14 line 13-14, the authors explained that the shortest wavelength for SPEX is 450 nm and not suitable for ALH retrieval. Do you mean the shorter wavelengths such as UV band benefit ALH retrieval? More clear and straight forward sentences are suggested to be used. Moreover, this explanation for ALH retrieval is too simple and this may be only one of many reasons. I believe reading more related papers about ALH retrieval could help the authors explain this problem more clearly and deeply.
9. Some sentences in this manuscript are a little complex and confused, especially in section 1 and section 4. More concise sentences are recommended.