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Atmospheric Measurement Techniques Discussions

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

Anonymous Referee #3

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This article by Fu et al presents aerosol retrievals from three polarimeters (SPEX, RSP, and AirMSPI) deployed in the 2017 NASA-SRON ACEPOL aircraft campaign with the SRON aerosol inversion algorithm developed by Dr. Hasekamp's research group. The retrieval results are evaluated through comparisons with measurements from HSRL2 flown on the same ER-2 aircraft and available AERONET observations, as well as through the inter comparisons of retrievals among these polarimeters. Overall, this is a well-written and proficiently organized article. The results are sound and properly discussed. I agree with most of the comments given by Dr. Remer and other reviewers. Below I have a few additional comments that the authors should consider to address.

General comments:

1. Although the paper focuses on aerosol retrievals, surface is an important component in the retrieval process and is included in the state vector. A good characteri-

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zation of surface reflectance can significantly affect the retrieval accuracy of aerosol properties, which is especially true when aerosol loading is small (such as of the most ACEPOL cases). So, as a reader I would like to see some retrieval results for surface BRDF/BPDF properties and how the retrievals behave between different polarimeters.

2. The retrieval algorithm needs some more clarification in a few aspects of the radiative transfer calculations and the inversion configurations. These include: (i) which radiative transfer model and what are the relevant assumptions (such gas absorptions, Rayleigh scatterings, etc) in the radiative transfer assumptions? (ii) How the first guess of the state vector is defined? While the first guesses for aerosol parameters are mostly given, the paper mentions nothing about prior values for surface BRDF/BPDF parameters. (iii) It is not clear how the aerosol refractive index are treated, although it is mentioned to use the D'Almeida et al (1991) database. (iv) It is also not clear about how the weighting matrix (W) in the cost function is defined, as well as the threshold for the goodness of fit. Please refer to the relevant specific comments below for more details.

3. By reading the title of the article (Aerosol retrievals from the ACEPOL campaign), I would expect to see aerosol retrievals from different polarimeters and from their respective aerosol products. Are there any aerosol products available from the ACEPOL campaign with other existing retrieval algorithms? If yes, it would be more helpful to compare the aerosol retrievals from different algorithms. Such a comparison may also explain the consistent biases in the retrieved aerosol size (Figure 2), depolarization ratio and lidar ratio (Figure 7). Otherwise, I would suggest to make the article title more specific, for instance, by adding "using the SRON algorithm".

Specific comments

1. Page 4, first paragraph of section 2.1. Description about aerosol refractive index is too brief. Please clarify: (i) at which relative humidity (RH) is assumed for the D'Almeida et (1991) database, or a dynamic RH relationship is considered with ancillary meteo-

rological data? This is important as the inorganic aerosols are strongly hygroscopic. (ii) How the coefficients are defined for combining the aerosol species? In terms of volume concentrations? (iii) Are the different aerosol species internally or externally mixed in the calculation of modal refractive index? In addition, it would be helpful if the refractive indices used in this study being provided in a supplemental document.

2. Page 5, line 6. Please give the explicit expression for R(G).

3. Section 2.1. The number of elements in state vector for different sensors would be different because of the different number of spectral bands. I would recommend include a table to list the detailed elements (and numbers) of the retrieved parameters for individual polarimeters. Correspondingly, the selected bands and number of angles for each observation set (as described in section 3.1-3.3) can also be listed in the same table. This will give the reader a clearer picture about the retrieval configuration for different sensors.

4. Section 2.1. It is not mentioned in algorithm description about: (i) what radiative transfer model is used and how many layers of atmosphere is assumed; (ii) how the gas absorption are treated; (iii) How the Rayleigh scattering are calculated. Please clarify.

5. Page 5, Equation (2). Please clarify how the wright matrix (W) is defined to regulate the ranges of individual state parameters.

6. Page 5, Equation (2). It is not clear how the prior state vector is defined for surface parameters. Please clarify.

7. Page 5, line 15. It is mentioned here “Stokes parameters I, Q, U at the top of the atmosphere” are simulated, but it is not clear what is the TOA altitude as defined. Moreover, the ACEPOL measurements are taken at an altitude of the ER-2 flights. The radiative transfer model should simulate the radiances as observed at the flight level. Please justify.

8. Page 5, line 29. Is a constant threshold for Kai-Square used for all retrievals across different instruments? Please clarify.

9. Page 6, Equation (4). The symbol "G" is already used in equation (1) to denote hot-spot geometry factor. A different symbol should be used to avoid ambiguity.

10. Page 6, Equation (7). Are there any references for calculating the columnar depolarization ratio in this way? I recall some studies (sorry I couldn't find the paper) used layer extinction coefficient (rather than backscatter coefficient) as the weighting parameter.

11. Page 9, line 24. Do you meant to "Where the HSRL method is NOT available for the extinction products . . .."

12. Page 11, line 32. It seems the effective radius for coarse modes 4 and 5 are much smaller than the AERONET climatology as reported in Dubovik et al (2002). So why not define a large effective radius values for these two modes.

Reference: Dubovik, O. et al (2002), Variability of Absorption and Optical Properties of Key Aerosol Types Observed in Worldwide Locations, Journal of the Atmospheric Sciences, 59(3), 590-608.

13. Figure 28. Authors may consider to replace the background of Figure 28a with a true color image of the smoke plume. I have seen such a figure from AirHARP gallery. It would be even better if a retrieved AOD map for the smoke plume is presented here.

14. Page 13, line 23-24. It is mentioned here the smoke plume has large spatial variability that may contribute to the retrieval uncertainty. The suggestion above (#13) would at least give a visual expression how large the spatial variability is. In addition, the MAP algorithm would have challenge to retrieve AOD as different view angles see different location (thus AOD) of the elevated plume due to the parallax displacement. Can the authors provide some insights on how to addressing this challenge in the retrieval?

15. Finally, I would like to see a figure of retrieved particle size distribution for the smoke case, which would help interpreting the retrieval results listed in Table 2.

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