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Atmospheric Measurement Techniques Discussions

Interactive comment on "Evaluation of the Lidar/Radiometer Inversion Code (LIRIC) to determine microphysical properties of volcanic and desert dust" *by* J. Wagner et al.

Anonymous Referee #1

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Overall, this is a very good work presenting LIRIC, a new algorithm for retrieving the profiles of aerosol optical and microphysical properties, by combining column-averaged AERONET data with lidar measurements.

The description of the method is clear and thorough (a more extended description would be out of the scope of the paper).

LIRIC-retrieved particle concentrations are evaluated using the corresponding concentrations retrieved with the POLIPHON method. As seen in the text, this comparison is problematic, since the definition of fine and coarse modes is different for the two methods. Although some insight is given through the comparison of retrieved backscatter

coefficient profiles for fine and coarse modes, the comparison deems inconclusive, especially for the mixed case. In addition, POLIPHON and LIRIC uncertainties are not explicitly quantified. A further investigation of these uncertainties (by varying the minimum and reference heights, changing the overlap correction but also by taking into account the uncertainty in the density value used for the conversion from volume to mass concentration) would make this work more complete, but it is not mandatory. Irrespectively, an overall evaluation of the comparison of LIRIC and POLIPHON results, summarizing the assumptions of each method and including a discussion of the problems in error estimation, would be very clarifying and is necessary in the conclusions section.

Also, please provide in the conclusions section other methods that would be more appropriate to use for LIRIC validation (e.g. using airborne in-situ data?)

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1-10 "The recently... radius range from 0.194 μm-0.576 μm.": Needs rephrasing, e.g.: "The recently developed Lidar/Radiometer Inversion Code (LIRIC) was designed as a universal code for processing lidar/photometer network data, applicable to many different instrumental conditions and technical approaches. LIRIC uses the profiles of elastic-backscatter signals measured with multi-wavelength lidar and the spectrally-resolved column-integrated particle optical properties from photometer observations in a synergistic way (Chaikovsky et al., 2008, 2012). The main purpose is the retrieval of height distributions of optical and microphysical properties of fine-mode and coarse-mode particles. In accordance to the AERONET data analysis code, the method searches for the minimum in the bimodal particle volume size distribution in the particle radius range from 0.194 μm-0.576 μm."

11-13 "In this contribution... irregularly shaped dust particles.": The validation of LIRIC is done using POLIPHON results which though contain uncertainties as well, especially for mixed cases. It is better to rephrase this piece to reflect the validation method

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uncertainty.

16 “The inversion. . . to obtain. . .”: Change to “The inversion of AERONET sky radiance measurements to obtain. . .”

23 “The method”: Change to “LIRIC method”

18-22 “These overlap. . . heights of 150 m”: The overlap correction is associated with an uncertainty. Has this uncertainty been quantified and taken into account in the estimation of the signal dispersion at the later steps of the analysis (page 926 lines 7-8 “The incomplete overlap. . . height.”, page 931 lines 22-25 “Part of the systematic. . . overlap correction.” and page 932 lines 20-22 “In the case. . . with decreasing height)”)? Please discuss.

24 “Sun-sky photometers applied by AERONET”: Change to “AERONET sun-sky photometers”

28 “Sky radiance observations”: Change to “Sun and sky radiance observations” (see Dubovik and King, 2000).

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4-5 “Based on these microphysical properties, AERONET provides the optical characteristics (the AOT, the column volume concentrations. . .”: The AOT is not retrieved, it is measured. The volume concentrations are not optical properties. Rephrase accordingly.

7-9 “In a case when sky radiance observations are not available the AOT and the column volume concentrations are derived from spectral dependence. . .”: Change to “For cases when sky radiance observations are not available the AOT and the column volume concentrations are derived from the spectral dependence. . .”

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1 “RFOV”: Spell out the acronym.

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7 “. . .to increases the. . .”: Change to “. . .to increase the. . .”

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5-6 “In the case of 1064 nm. . . at the reference height.”: What is the estimate used in the analysis?

11-12 “To assure optimized profiles. . . within error margins.”: Provide reference on optimization method.

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4-10 For Eq. 7, 8, 9 provide explanations for symbols used (e.g. ω, F11) immediately after. (The explanations are provided in the text, but further below.)

16-17 “A fixed fraction. . . for the fine mode...”: Provide the value of the ratio.

22-24 “Besides. . . data set.”: Make more explicit the option of including the cross-polarized 532 nm backscatter signal. Rephrase to: “Besides the elastic backscatter signals for 355, 532, and 1064 nm, LIRIC algorithm provides the option of including the cross-polarized 532 nm backscatter signal (denoted as 532c in Fig. 1, wavelength index j=4) in the input signal data set.”

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1-2 “Consequently, . . . non-spherical particles.”: Rephrase it to highlight that if the cross-polarized signal is not provided LIRIC does not provide results for non-spherical particles.

13-14 “The retrieval is designed. . . in Dubovik, 2004).”: (OPTIONAL) Change to: “The retrieval is designed as statistically optimized fitting of multi-source data, using the multi-term LSM (see detailed description in Dubovik, 2004).”

15 “. . .is organized as minimization. . .”: (OPTIONAL) Change to “. . .is organized as the minimization. . .”.

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17-8 “. . .photometric measurements and retrieved concentration profiles,. . .”: Change to “. . .photometer-derived column volume concentrations and corresponding integrals of the retrieved concentration profiles,. . .”.

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1-2 “The mean value of the different solutions. . . 5-10 different solutions.”: Discuss why you didn’t take into account the minimum and reference height uncertainty in the error estimation.

Page 923

8-10 “. . .are caused by. . . related to the coarse mode.”: Rephrase “. . .are caused by non-depolarizing spherical particles (i.e. fine-mode fraction), and that the coarse mode are strongly light-depolarizing non-spherical particles.”

25 “. . .required. . . in addition).”: Change to “. . .required in the LIRIC data analysis).”

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20 “Stable conditions. . .”: Since you provide evidence for these “stable conditions” below (page 926, line 10), rephrase as “Stable conditions (see discussion bellow). . .”

23 “. . .,21:47 to 23 15 UTC. . .”: Why using such a broad time frame? Especially since after 22:45 there is an obvious change in the vertical distribution of the aloft plume (see Fig. 2). Discuss.

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1-2 “Figure 3. . . as retrieved with LIRIC”: (OPTIONAL) Move line 19-20 here to highlight the absence of spherical coarse mode “Figure3. . . as retrieved with LIRIC. The analysis indicated the absence of spherical coarse-mode particles throughout the troposphere.”

2-5 “As mentioned. . . AERONET observations.”: (OPTIONAL) Rephrase as “As mentioned, the vertically integrated fine- and coarse-mode volume concentrations must

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match the respective column values retrieved from AERONET observations."

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6-7 "According to Fig. 5... AERONET column observations": Rephrase according to the fact that the AERONET column observations are actually used in POLIPHON analysis. Thus, POLIPHON results are not as independent from the AERONET column observations as it is implied in the phrase.

10-13 "The fine-mode... POLIPHON curve.": If this is true, the agreement in the coarse mode should be re-evaluated under this light. Furthermore, this discrepancy may be also due to the density used for the non-spherical fraction of fine mode (p2 in Eq. 11) for the conversion of LIRIC fine mode volume to mass concentration (this also applies at page 932 lines 18-19 "Regarding... AERONET column value."). Did you take into account the range of possible densities in the LIRIC and POLIPHON mass concentration uncertainties? Discuss.

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5 "...transport from the west": (OPTIONAL) Provide reference.

25-28 "Cumulus cloud... in the coarse mode.": Then, this is probably a failure of LIRIC to retrieve the spherical coarse mode in this case. Please include in the conclusions section.

Page 932

9-25 "As can be seen... acceptable.": Provide the densities (p1 and p2) used.

Page 933

16-17 "...indicated a good... with LIRIC.": As mentioned in the beginning of this review, please rephrase and include a discussion about the comparison of LIRIC and POLIPHON results for each case separately (emphasizing that the mixed case is more problematic), as well as the problems in error estimation for the two methods.

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Fig.1 “LIRIC products (blue box)...depolarization ratios)...”: Provide the symbols of the properties, as seen in the figure.

Fig.1 –last line “...and respective mass concentrations Mf and Mc for fine and coarse mode.”: The mass concentrations are not “LIRIC products”.

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Fig.3 (OPTIONAL) Change the “Coarse mode” in legend to “Non-spherical coarse mode”. Do the same in Fig. 4, 5, 8, 9 and 10.

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