

# ***Interactive comment on “A methodology for investigating dust model performance using synergistic EARLINET/AERONET dust concentration retrievals” by I. Binietoglou et al.***

**Anonymous Referee #2**

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The authors present modeling results of 4 different dust transport models. Several data products (e.g. integrated dust concentration, peak mass concentration of dust vertical profiles, vertical profiles of dust mass, ...) are compared to data products derived from lidar-sunphotometer observations with LIRIC. The data products represent four areas: Spain, Italy, Greece and Central Europe.

The manuscript needs significant improvement with respect to LIRIC. Little information is provided with regard to the LIRIC retrievals, the model itself (though a paper on LIRIC has been submitted), and the quality of the measurement cases used for this study. I am also missing an error analysis of the LIRIC results and an uncertainty analysis of

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the modeling results.

Page 3614, line 18 and following lines: the forward scattering computations are typically based on Mie theory. It is an old problem that Mie theory still is the choice of light scattering model, even if dust properties are modeled. If Mie theory is used in deriving (some of) the modeling results the authors need to provide an uncertainty analysis. In how far does Mie theory create uncertainties that make it virtually impossible to compare your results to the LIRIC results? Do you find good agreement for the wrong reasons? AERONET retrievals are based on a different light-scattering model. It would be very helpful, if you showed error bars for each of your data points, e.g. Figure 5 (and many other figures); another option would be if you showed characteristic error bars for some data points. You should also include information on the extreme (maximum) uncertainties.

What was the quality of the lidar profiles in general? The LIRIC algorithm certainly requires a reasonable signal-to-noise ratio in order to derive meaningful profiles of the data products used in this study. What optical depths did you find for these cases? Did these optical depths fulfill thresholds required for the AERONET retrievals? Did you check if the aerosol conditions remained constant (homogeneous in time and/or space) between the AERONET observations and the lidar measurements. Did you check time series of optical depths, time series of backscatter profiles (or at least the range-corrected backscatter signals)? Did you check temporal/spatial variations of Angstrom exponents (backscatter related and/or extinction related if multiwavelength Raman lidar data were available) during the time between AERONET and lidar observations? Your manuscript does not show that you considered any of (respectively all) these potential quality assurance tests (there are more tests available like checking time series of depolarization ratio profiles and curtain plots) before you derived the dust profiles with LIRIC. Please provide a table in which you list the optical depths for these cases. Also list information on variability of optical depths, Angstrom exponents, backscatter coefficients and illustrate by how much these parameters changed between lidar and sun

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photometer observations. One or two concise scatter plots might be another option. It would be helpful if you also show comparisons of modeling results of extinction profiles (can they be provided by the models?) to Raman lidar measurements (many of the stations can provide you with extinction profiles, even if they are not used in LIRIC). This comparison would provide additional proof of the quality of the modeling results.

Page 3616, line 3: “constant microphysical properties” are assumed throughout the atmosphere. Please provide sufficient evidence in your paper that microphysics did not change significantly for the case you used in this paper. Otherwise this study is affected by a large unknown error source. Page 3610, line 6: “under certain assumptions”. Please be specific about what these assumptions are, how they affect your results, and if measurement situations of (mixed dust) were present for the cases considered here. I am also wondering if the model results naturally end up in a bias, as the models are used for dust modeling, whereas LIRIC can be used for dust, mixed-dust and non dust cases. In how far were the “dust cases” used in this study significant enough (e.g. dust optical depth). Can you compare dust modeling to LIRIC retrieval results of “dust” profiles as the plumes may have contained other aerosol components?

Page 3616, line 16: you write that “LIRIC has proven to be a robust algorithm for aerosol volume concentration retrieval”: I take issue with this comment. I am not aware of any study in which the LIRIC results were compared to direct measurements of volume concentrations, e.g. by carrying out in-situ measurements of particle size distributions (e.g. aircraft measurements). Please rephrase such comments and discuss the results of LIRIC. You need to make clear that LIRIC has not been validated. Explain why you have confidence in the LIRIC results. Provide references to corroborate your explanations. Show an uncertainty analysis. Please also remove comments like “actual size distribution” (line 9, page 3610), as this implies that LIRIC “measures” size distributions.

Section 2.2, page 3613 and table 1: please be more specific how the data products in table one are related to the methodology, particularly as some data products are

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retrieved (LIRIC), some can be measured, some data products may be more of qualitative nature; again: LIRIC has not been validated with independent methods.

Page 3615, description of LIRIC and reference to Chaikovsky et al.: please provide a short description of LIRIC. Chaikovsky seems under review. Most of the references are not peer reviewed literature. As the LIRIC results are at the core of your study it is justified that you outline the most important parts of LIRIC in this paper. Please provide a discussion of the errors and assumptions involved in LIRIC retrievals and by how much LIRIC results might be biased. It may not necessarily be the case that only the model results are biased.

Page 3619 (lines 5-27) – 3620 (lines 1-7) and also rest of section 3: This section is about the methodology, but it is kept very unspecific. Please provide hard facts, numbers, and references. A case study would help significantly in explaining the various concepts explained in this part of the methodology section.

Page 3624, lines 26/27 (I am mainly repeating what I already wrote before): you write that the time difference was kept small. This is not sufficient. Did you check if wind direction changed between lidar and sun photometer measurement? I do not find information on the possibility that, e.g. the center of mass (peak of the backscatter profiles can certainly be used as an approximation) changed between lidar and sun photometer observations. Such a variation would distort the profiles (from LIRIC), and I am wondering if such an effect would lead to a misinterpretation of the quality of the modeling results. Did you check if optical depth between time of lidar and SPM measurement change? That might indicate a change of (at least) extensive properties. How can you rule out that intensive properties did not change? Please provide some evidence that the lidar and sun photometer data did in fact provide optical data that describe similar aerosol conditions, regardless of the temporal differences between lidar and SPM measurements.

Page 3625, line 14 – and following lines: you compare center of mass and peak value

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of mass. It might be worthwhile if you include modeling results that do not only describe the grid point of the lidar/sunphotometer location. It certainly could be the case that the model puts the center of mass at a neighboring grid point in a different height. It would be helpful to know if differences of center of mass are less (or larger?) if you use neighboring grids. In fact, such an analysis would also be helpful for the other data products.

Line 5, page 3626: please avoid giving the reader the impression that LIRIC provides the truth (“the model underestimated the total amount of dust”). There are too many model assumptions involved in LIRIC and there is no independent study that would allow us to judge for which measurement situation LIRIC is correct.

Page 3607: dust models are validated with optical depths data?

Section 3, general comment: I think a considerable part of the text belongs to the introduction. This part of the methodology section is very unspecific. I would like to see a case study in which you guide the reader through an example: data, LIRIC data products, modeling results, including uncertainty analysis. The figures show a nice overview on the analysis of many measurement examples taken from several stations. But it is nearly impossible to judge, how well LIRIC performs.

Please combine figures in plates. This would make the paper more organized in view of the relatively short text. I suggest that you combine Figures 4 – 7 into one plate, Figure 8 and 9 into one plate, figures 10 -13 into one plate, and figures 15, 16 into one plate.

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