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Atmospheric Measurement Techniques Discussions

Interactive comment on "Experimental techniques for the calibration of lidar depolarization channels in EARLINET" *by* Livio Belegante et al.

Anonymous Referee #3

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The paper explains calibration procedures for lidar depolarization measurements and compares and contrasts various methods used in EARLINET. This will be a very useful reference for EARLINET operators and for those wishing to understand the data quality of EARLINET depolarization measurements. I would like to see it published. However, the manuscript suffers somewhat from a sub-optimal organization related (perhaps) to a confusion about its primary purpose.

I have two major concerns. First, I spent hours just trying to understand the paper. This included a lot of time paging back and forth to find variable definitions. There are 16 variables in the first equation which are explained in a somewhat scattered way in the following paragraph, and ultimately the final equation of the theory section includes 25 variables, only some of which are the same as in Eq. (1). This is many more variables

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Discussion paper

than I can keep in my head at once. Later sections refer to quantities only by variable name without any verbal description or reminder of what the variable means as if we have everything memorized. It was good to see the list of variables at the end, but this is not sufficient. If this paper is going to be useful for its recommendations or as a reference for data quality, it should be written clearly and consicely for a target audience who will probably want to use it practically, not theoretically. While it's admirable to see the theory treated in such a thorough way, I'm not sure there is anything new in the theory section. Rather, I think the purpose of this section should be to lay the foundation for understanding the calibration procedures and results that will be discussed in later sections. To that end, is it possible to streamline the derivations and to present the equations in a simplified way such that they clarify the relationships between the quantity you would like to assess (a or delta), the quantities that are more directly measured (Stokes vectors) and the calibration parameters that are going to be discussed (diattenuation parameters and offset angles), without every detail of scattering theory being included? I have to admit that ultimately I failed to thoroughly understand the theory section although I am familiar with these concepts using different equations and different variable names and symbols. So possibly I'm wrong and all this really is indeed needed. In that case, it is even more important to make this section pedagogically clear. Describe in words the purpose of each part of the derivation, end sections with the most simplified useful version of the equations (like the equations that undergraduate textbooks enclose in a box), and restate the variable meaning and not just the symbol each time a variable is reintroduced in a later section. You'll need to write it as if you are teaching it, not just demonstrating that you know it well yourself.

My other concern is about the results section. You have stated two purposes, given at the start of section 4.4: to present the importance of calibrated depolarization products and to assess the accuracy of the calibrated depolarization products. I suggest that the first purpose is misplaced here. Except for the brief discussion in the introduction that can be seen as motivation, this paper doesn't need to show the importance of calibrated products. The second objective, to assess them, is of far more importance,

and there is room for improvement in how this objective is addressed. It's good that you have examples to show that the measured depolarization is close to the expected value, especially for the aerosol-free molecular depolarization which is known independently. This should be expanded. Is there any other simultaneous data available for independent assessment or inter-comparison? Other than these comparisons, you also have error bars which can give an idea of the precision of the depolarization measurements. Please be more thorough in explaining how the error bars are calculated and make sure they are consistent in the various comparisons, because these are a large part of the rather small set of information available to assess the results of the calibrations presented.

Specific comments:

Page 1, line 4. Which "derived parameters". Please be specific in the abstract.

Page 2, line 18. What are "all relevant parameters". I think "all relevant parameters are shape dependent" might be a bit of an overstatement, but the rest of the paragraph does a good job of explaining when depolarization measurements need to be highly accurate and when they are used just in a relative sense.

Page 2, lines 25-30. These two sentences should be rewritten to make your point more clear. What do you mean by "ranges around close values", that the depolarization values are clustered well so that different types are distinguished easily, or the opposite, that different types have similar values and can't be distinguished unless the depolarization is very accurate? What does "The same issue" refer to?

Page 3, line 27 - Page 4, line 11. With so many variables, it would be helpful to organize the descriptions more predictably. Please either describe all the variables left to right, including the dependent variables, or else describe all the dependent variables and then all the independent variables. Or simplify as discussed in the general comments above, and then maybe fewer variables will be needed.

page 4, line 22. A new variable ε is introduced without being explained.

page 7, lines 2-9. "For most cases we consider" suggests there is a much simpler version of the equation that is being used for the rest of the paper. Please give this simpler version explicitly.

page 7, Eqn 20. Is the variable η the same as the sub-scripted variable η_s from Eqn 1?

page 9, line 11. Spell out acronyms, Half Wave Plate

page 13, line 11. Reintroduction of variable Y after 4 pages. Here is an example where it would be easier to follow if you remind readers what variable Y means and where it was introduced, something like "Y, which was introduced in Eq. (24) and is mathematically related to the error angle". Or better yet, since the error angle is a more familiar variable than Y, maybe consider recasting the plots in Fig 5 to use error angle instead of Y.

page 13, line 22-27. Here is the first time where you make it explicit that correcting errors in the angle with hardware is better than post-processing. I found it very confusing before this part of the paper. While I understand that this paper aims to treat all methods of calibration used in the various EARLINET instruments, the earlier discussion of the two methods (that is, hardware correction and analytical correction in post-processing) did not make a clear distinction between them and I was left wondering if for some strange reason the authors were only considering the post-processing solution, which is the less desireable one. Please do everything you can do to make all options clear from the start and to be certain to distinguish clearly between calibration methods that change (and therefore correct) the angle errors from methods that do not change them (and therefore have to mathematically adjust the results in post-processing) at every stage of the discussion. Don't leave any mysteries to be solved at the end of the paper.

page 17, Conclusion section. This section is good. It is very helpful that the calibra-

tion methods are summarized again here because it helps to clear up some of the confusions from earlier in the paper.

Page 18, line 20. "Proper corrections". Please make this sentence more specific. Are you talking about only the diattenuation correction here, or also about the angle corrections?

Page 18, lines 22-30. This discussion is critical to your assessment of the calibration results. It is out of place appearing for the first time in the conclusions. This should be part of the results and discussion, and it should be expanded.

References: the last 3 references are out of order.

Figure 4b. I'm confused about why the true and measured depolarization values don't agree even at an angle error of zero. Is this because there are other calibrations that have not been applied? Given that the point is to show the effect of angle error on the depolarization, then I think the angle error should be the only uncorrected error in the simulation.

Figure 4 caption. There is a typo. The range of alpha is 0 to 10 degrees, not -10 to 10.

Figures 8,9,10,11. What do the error bars represent (systematic or random, empirically calculated from data variability or theoretically calculated)? Please explain in the figure caption and in the text.

Figure 9. Why is there no depolarization data below 2000 m?

Figures 8,9,10,11. Please make all the y-axis lower limits the same for all the sub-panels in a given figure.

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