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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of Intensive Aerosol Microphysical Parameters from Multiwavelength Raman/HSRL Lidar: Feasibility Study with Artificial Neural Networks" *by* M. Mustafa Mamun and Detlef Müller

Anonymous Referee #1

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The topic of this manuscript is of interest for atmospheric science. The language itself is acceptable, but often the descriptions are vague and sometimes different terms are used for the same thing. Furthermore, the advantages and disadvantages of this new approach are not well discussed. I'm afraid that the manuscript is only of limited usefulness in its current state. The paper needs strong revisions before it may become publishable in AMT.

General comments:

1) First, I have to say that I'm not familiar with ANN. Though the authors try to explain

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Discussion paper

the ANNs, their explanation of ANN in general and how they use ANN for lidar data inversion is not easy to follow and also sometimes confusing. Unfortunately, I was not really able to figure out how exactly the presented calculations were performed. Some specific points are mentioned below. In any case, the description of the methods needs to be improved significantly before this manuscript can be published.

2) Uncertainties: As the uncertainties of some retrieved parameters are (generally from the physical point of view) determined by the measurement uncertainty in combination with the assumed model (here spherical Mie particles), the presented uncertainties have almost nothing to do with the real uncertainties of the retrieved parameters. In addition, ANN provides some kind of black box, and thus it seem unlikely to me that ANN will ever be able to provide physically consistent quantification of uncertainties of retrieved parameters. Despite these limitations and keeping them in mind, ANN applied on lidar data might be useful for operational purposes if it has significant advantages (e.g. with respect to speed) compared to other methods.

Independent of such considerations, it is mandatory for a feasibility study to consider measurement uncertainties because they can lead to a non-feasibilty of the whole approach. In my view, this is a significant gap in this manuscript, which needs to be filled somehow, as long as this study is called feasibility study.

Some specific comments:

What is the mean radius of a log-normal distribution? The average radius? Usually, log-normal distributions are parameterized with a "mode radius" (which is the median radius) and some parameter for the width of the distribution. The mean radius is not the same as the mode/median radius. Please clarify which of these radii you mean. Adding the formula for the log-normal distribution might be useful.

Line 16-17: It remains unclear why ANN would be particularly useful for the investigation of the information content of optical data. A consistent uncertainty treatment would be necessary for that (see also general comment 2).

Line 32: Extinction-based angstroms are only available when 2 alphas are available. So it remains unclear how this and the previous sentence are related.

Line 53: Remove "profiles of".

Line 140-144 are very unclear.

Line 149: The meaning of "... an algorithm, i.e., perceptron named the ..." is unclear.

Replace "true solution" (e.g. line 151) by "true value".

Line 151: "in which the network errors ... again check for new weight values" does not make sense.

Line 157: What means "fixed random bias value"?

Line 161/162 is confusing. I though the activation function is given in Eq. 1 and is not a sum.

Line 173-175: I do not really understand what would be the benefit of using the output value as input. If you know the output value you don't need any algorithm because you already have the value you want.

Line 263: "more than 3 hours at least." Is this really an issue for the training phase?

Line 263: What means "data downscaling"?

Line 289-290: What is the use of subdividing the "training data" in 'training', 'testing', 'validation'? This is not explained. Subdivision of "training data" into 'validation' seems odd by itself. Looking at the tables there seems to be almost no difference in "R^2" between the 'training', 'testing', 'validation' data sets. Please explain why this subdivion is necessary.

Line 462: "For the first time to our knowledge" could be removed.

Line 469: This is the range of "mean radii" (Tab 1.), but your size distributions also contain radii larger than the mean radius.

Line 479-480: Is this really necessary? The data in table 1 shows that you already have size distributions with effective radii larger than 4 mircrometer. Are larger effective radii really relevant for atmospheric science? If yes, do you expect that lidar with a maximum wavelengths of 1064nm would be able to quantify such aerosols?

Table 1: Do you really use 10011 imaginary part steps?

Table 1: I don't understand the meaning of the rows below imaginary part. I though "N" would be the number of cases in certain ranges of reff, real part, and imaginary part, that are defined in the parameter/value lines in the same table. However, there are 198 million combinations defined in the parameter/values lines, but the sum of N for reff is about 1.6 million, for the real part and the imaginary part 0.9 million. What does that mean?

Table 2: Why use "EC"/"BC" if there is already alpha and beta?

Tables: What is the difference between "Rˆ2 value" and "Adjusted Rˆ2"?

Table 3, 4, 5: Values in "Training Statistics, Rˆ2 value Training", "Training Statistics, Rˆ2 value Testing", "Training Statistics, Rˆ2 value Validation", "Simulation statistics, Pearson's r" are almost the same for each input combination. In particular, can you explain why the "Pearson's r" values are almost the same as the "Rˆ2" values?

Figure 1: There are several arrows that don't make sense. For example, what is the meaning of the arrow from "ANN topology selection" to "Five basic data combinations"?

Figure 1: Results shouldn't be included in a flow chart, references to tables, figures, sections are sufficient.

Figure 3: Why use microphysical properties as input? This doesn't make sense in my view.

Figure 3: Add units.

Figure 4: What is the meaning of "1" in the circles?

Figure 5: Why are there numbers in this plot?

Figure 6-13: Try to reduce the number of subplots and try to make them larger.

Table 10: The network architecture for ANN #10 should be "traingdx" according to the text.

It seems that "ANN" and "NN" are used interchangably in most parts of the paper. I suggest to use only a single abbreviation.

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