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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Retrieval of aerosol optical depth from surface solar radiation measurements using machine learning algorithms, nonlinear regression and a radiative transfer based look-up table" *by* J. Huttunen et al.

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GENERAL COMMENTS

I read the manuscript with interest, especially considering that it performs a comparison of several multivariate techniques for modeling/estimating aerosol optical depth (AOD) using surface solar radiation (SSR) measurements. As the authors point out, long time series of such measurements are available and this can be exploited to reconstruct a coincident record also of AOD. Extrapolation of AOD back in time is something that will be very useful in studies of radiative forcing but also climate change trends. The

availability of long time series of AOD estimates will also help enrich models of other atmospheric variables that would benefit from inclusion of this important parameter. The study of AOD in the context of SSR is a very active field (a CrossRef metadata search with +"aerosol optical depth" +"solar radiation" with the "journal article" flag on returns a large number of 953,336 results), and it is good to see a study that is targeted at AOD retrieval in particular. The authors idea of comparing machine learning models is timely, well grounded and relevant to the scope of the journal of Atmospheric Chemisty and Phyics (ACP). Several of the authors were instrumental in a recent ACP paper to derive effective AOD from pyranometer measurements of SSR, by comparing the capabilities of several modern approaches, the submitted manuscript builds on this work and provides a useful feasibility study for the ballpark accuracy of AOD retrievals from irradiances using advanced models.

Methodological issues:

1) On Page 4, lines 7-9, the authors describe how they have chosen to compare neural network (NN), random forest (RF), Gaussian Process (GP) and Support Vector Machine (SVM) models of the AOD against look-up table (LUT) and nonlinear regression models. Comparative studies of this type are becoming more popular in the literature, but it should be born in mind that results are sensitive to model specification and, in particular, the number of free parameters (e.g. Ljung, 1998). For example, in the context of NN architectures alone, these include the number of neurons in hidden layers, the number of such layers, training:validation data partition sizes, neuron activation functions used). It is also rather challenging to find optimal values for model parameters. For example, Meyer et al (2003) compared a SVM alone against 16 classification methods and 9 regression methods in R. The same could be said for all of the methods adopted in the submitted manuscript. With this in mind it would be good if the authors could either:

a) increase the depth of the study by performing a thorough sensitivity analysis on the free parameters used in each of the nonlinear modeling approaches (NN, RF, GP, SVM, and NR) to help constrain the optimal values and number of free parameters needed to achieve different model performance, or

b) emphasize more how the study performs a feasibility type of analysis of the specific nonlinear models adopted for producing AOD retrievals of certain quality.

2) On Page 6, lines 8-11, the authors describe how the training dataset for the machine learning methods contained years 2009-2014 and the validation (verification) dataset contained the previous years 2005-2008. I would like to see the authors describe why this partition was chosen (over others) as well as a short presentation of the basic exploratory statistics of these datasets: i.e. the means and standard deviations and min-max values of the model input and output parameters. This will help the authors to make stronger claims about the generality of the models selected.

SPECIFIC COMMENTS

I would say that the level of technical English in the submitted manuscript is reasonably good, as is the level of scientific description. A couple of minor points:

3) On Page 3, lines 6-7, I disagree that AERONET has rather good spatial coverage. Even on a global grid of 1 degree resolution (180 x 360 pixels), the occupancy of global pixels, is extremely low dispite there being of the order of 10ˆ3 sites.

4) On Page 3, line 15, I would say that the (satellite and AERONET AOD) records extend a between 1 and 2 decades into the past. On the daily timescale, this could be arguably be considered to be a fairly long time-series record.

5) I would make the font size bigger in Figure 1 and Figure 6.

6) In Figure 5, colour is associated with WVC and the title would be better placed vertically on the colour bars as "WVC [cm] (LUT)" and "WVC [cm] (meas.)" or something along these lines.

CONCLUDING REMARKS

Given the importance of accurate AOD estimation and the potenial for increasing the capacity for monitoring long-term changes in climate forcing where AOD is a key parameter, the submitted manuscript is a useful addition to the literature and would benefit I hope from these minor revisions.

REFERENCES

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