This document contains the authors' responses to the Editor's comments. The Editor's comments are in black, followed by the author's responses in blue.

GENERAL COMMENTS

The manuscript (v3) has improved significantly. It is recommended to be published after the remaining issues listed below have been addressed.

Main comment

The choice of data used for training, testing, and evaluating the SVR algorithm needs to be explained more clearly and upfront e.g already in the introduction, or in a dedicated subsection in section 3 (similarly to Section 2.1.2 for Experiment I). Is the scheme trained and tested on OMEARUV (augmented with CALIOP) and AERONET data? Is the scheme applied in case studies to UVAI and ALH data from S5P/Tropomi observations and AOD from MODIS?

We have separated the Section 3.2 into 2 subsections and modified the content, please have a look. In 3.2.1 Collocating OMI and AERONET observations collocation, we explain the data source and preprocessing for preparing the training and testing data set. In 3.2.2 Feature selection, we explain how we select input features (UVAI, ALH and AOD) and the output (AAOD) based on empirical knowledge and Spearman's rank coefficient.

The SVR model is trained and tested on OMEARUV-AERONET joint data set as explained in line 273-274: *The SVR model is trained and tested base on the OMAERUV-AERONET joint data set containing 8616 samples as described in the last section (consisting of UVAI, ALH from OMAERUV, and AOD, AAOD from AERONET).*

The trained SVR model is applied to TROPOMI UVAI and ALH and MODIS AOD as explained in line 340-341: *For all applications, the input parameters in the SVR model are TROPOMI UVAI (calculated by 354 and 388 nm wavelength pair), TROPOMI ALH and MODIS AOD, respectively.*

Minor comments

Line 10-11: sentence incomplete

The sentence has been modified into: *The purpose of this study is to demonstrate the role of aerosol layer height (ALH) in quantifying the single scattering albedo (SSA) from ultraviolet satellite observations for biomass burning aerosols. (line 10-11)*

Line 18-19: the sentence "This empirical method is free from the uncertainties triggered by a priori assumptions ..." need to be reformulated. A) uncertainties are not "triggered by a priori assumptions". You might consider a formulation like "uncertainties due to imperfection a priori assumptions"; B) You can state that a priori assumptions do not appear explicitly in this empirical method, but it needs to be acknowledged that unknown variability in micro-physics contributes to the uncertainty of the results obtained using the empirical method.

Thank you for the suggestion. The sentence has been modified into: *This empirical method is free from the uncertainties due to the imperfection of a priori assumptions on aerosol micro-physics as that in the first experiment. (line 18-19)*

Line 24: sentence incorrect "is better agrees"

The sentence has been modified into: … *and the latter better agrees with SSA from MERRA-2 reanalysis. (line 24)*

Line 35/36: add that the index is sensitive to ELEVATED absorbing aerosol. This feature is important in the present study.

For the sake of the coherence, we have added this in line 30: *It detects elevated UV-absorbing aerosol layers by measuring the spectral contrast difference between a satellite observed radiance in a real atmosphere and a model simulated one in a Rayleigh atmosphere (Herman et al., 1997)*

Line 75-76 the sentence "From our perspective, ML techniques can avoid making assumptions on poorly-understand aerosol micro-physics as that in the first experiment." . . ." need to be reformulated. Proposed: "We employ ML techniques in order to avoid explicit assumptions on aerosol micro-physics as made in the first experiment."

Thank you for the suggestion. The sentence has been modified into: *We employ ML techniques in order to avoid explicit assumptions on aerosol micro-physics as made in the first experiment. (line 74-75)*

Line 83-84: We will present the capability to retrieve SSA from UVAI of USING this empirical method with multiple case studies.

The sentence has been modified accordingly: *We will present the capability to retrieve SSA from UVAI of using this empirical method with multiple case studies. (line 82)*

Line 85 replace "implemented" by e.g. "outlined"

The sentence has been modified accordingly: …, *the first experiment is outlined in section 2, … (line 83)*

Line 91 replace "implement" by e.g. "outline" or "report results from"

The sentence has been modified into: *In this section, we present the first experiment that retrieves SSA by radiative transfer calculations as done in previous studies (Colarco et al., 2002; Hu et al., 2007; Jeong and Hsu, 2008; Sun et al., 2018). (line 89-90)*

Line 197: sentence incorrect "from as an alternative"

The sentence has been modified into*: In this section, we propose an empirical method to derive SSA as an alternative of the radiative transfer simulations presented in the first experiment. (line 195-196)*

Line 199: replace "understanding to" by e.g. "knowledge of"

The sentence has been changed accordingly: *..., whereas our knowledge to them is inadequate (particularly the aerosol absorption spectral dependence). (line 197-198)*

Section 3.4 introduces SVR hyper-parameters tuning and explains theoretically the potential need for different values of the parameter 'p' to account for statistical differences between training and test data sets. The text remains vague about whether this is actually needed in the present case. Table 3 lists only one single value for p, which suggests is it no needed here. Please clarify, and streamline.

The kernel width parameter p is one the hyper-parameters of an SVR algorithm with RBF kernel. p is determined by hyper-tuning process. In other words, we try different values of p, from which we find the one that leads to a small error when predicting for the training data set meanwhile the difference between training error and testing error is also small.

The hyper-tuning process is actually presented in Fig.7. We present the RMSE of training process, the difference between RMSE of training and that of testing process, and the final retrieved SSA as a function of the three hyper-parameters. The C and $\boldsymbol{\varepsilon}$ are determined directly by Eq (9) and (10). We indicate their values by the black cross mark. The remaining parameter p is determined by using three different values (for the sake of simplicity, we present its value in the form of p^2). From Fig.7 we can conclude that when p^2=1.67, the RMSE of training process is relatively small, meanwhile the difference between errors in training and testing process is relatively small. Table 3 lists only the optimal choice of hyper-parameter values.

We actually mentioned it in the manuscript in line 293-294: *..., where p is the kernel width parameter that reflect the influencing area of support vectors. This parameter is determined by hyper-tuning on the testing data set (Durbha et al., 2007) (explained below).* The following paragraph explains the hyper-parameter tuning as described above (line 295-306).

Line 421: remove "d" in "potential to retrieved SSA"

The sentence has been modified according: *In this study, we present the potential to retrieve SSA based on the long-term data records of UVAI, ALH, AOD and AAOD using a statistical method. (line 423-424)*

It is repeatedly mentioned that "The input features are selected by the Spearman's rank correlation coefficients", which raises more questions than it answers. The rationale should be explained more clearly. (Near Line 265 it is explained that AAOD is chosen as output parameter of the SVR scheme rather than SSA in view of the difference in the correlation coefficients. Is that what is meant with selection of input features?)

The model input features should be correlated with the model output. According to Fig.6, the SSA shows low correlation with the UVAI. On the other hand, AAOD is highly associated with UVAI and AOD. As a result, we use AAOD rather than SSA as the output of the SVR model. Moreover, one cannot interpret UVAI without information of aerosol loading (AOD) and aerosol layer vertical distribution (ALH). Thus, we built up an SVR model with UVAI, AOD and ALH as input features and AAOD as the output.

We have modified the section to make it clearer in section 3.2.2: *The OMAERUV-AERONET joint data set consists of following parameters: UVAI calculated by 354 and 388 nm wavelength pair, satellite geometries, surface albedo, surface pressure and ALH from OMAERUV, and SSA, AOD and AAOD from AERONET. Fig.6 presents the Spearman's rank correlation coefficients matrix (ρ) of those parameters. It is clear that except for AAOD, SSA is barely associated with other parameters. The correlation between UVAI and SSA is rather low (ρ = -0.26). On the other hand, AAOD is highly associated with UVAI (ρ = 0.71) as well as AOD (ρ = 0.75) as it carries information on both aerosol absorption and aerosol loading. Therefore, it is preferred to predict AAOD from given UVAI and derive SSA via in Eq. (2) afterwards rather than to directly predict SSA from UVAI. Besides, as mentioned previously, AOD and ALH are the major factors influencing UVAI, which is also reflected by the relatively strong correlation in Fig.6. Consequently, we construct an SVR model with UVAI, ALH and AOD as the input features, and AAOD as the output. (line 261-270)*