Reply to comments of Referee #1.

The authors would like to thank Referee #1 for careful reading of the manuscript and valuable comments.

Comments:

1. The abstract is too long and difficult to understand.

   We reduced abstract by ~20% which we think makes it more concise and clearer.

2. The paper is overloaded with abbreviations. Many readers who are interested in details of AERONET retrieval algorithm will want just quickly browse the paper. In this case, the text is often too difficult to understand due to abbreviations that are not very common.

   For easy reference, we summarized the list of abbreviations in Table A1. At the same time all the abbreviations were removed from abstract to make it easier to read without need to look for meaning of each abbreviation. I addition, we changed some abbreviations to more commonly used in aerosol community: ASD was replaced by PSD.

3. Row 77. "Absorption at 380 nm is particularly important as this is the wavelength range that satellite observations and algorithms are able to retrieve atmospheric column absorption from existing (Jethva et al, 2014) and future satellite sensors (Werdell at al., 2019)" . This statement should be clarified. Is it due to low aerosol optical depths at longer wavelengths?

   The following explanation was added to the manuscript: The unique utility of measurements in UV for satellite remote sensing is related to increased sensitivity to aerosol absorption due to absorption of molecular scattering by aerosols (e. g. Torres et al., 1998)

4. Equation (3) is discussed too briefly, it is better to say a few words about what each term in it represents, rather than just defining the variable.

   The following sentence was added: Jacobian matrices are the matrices of the first derivatives of measurements with respect to retrieved parameters and covariance matrices are diagonal matrices with elements equal to the accuracy (variances) of the measurements and/or a priori estimates.

5. There are two γ variables in the equation (3), Lagrange multiplier γ_n (row 149) and Lagrange multiplier γ_k (row 146). Later in the text the authors discuss the Lagrange multiplier γ_3 (row 164). It is necessary to write explicitly which one Lagrange multiplier is considered.

   To avoid confusion the following changes in equation (3) have been made: the separated symbols were introduced for Lagrange multipliers contributing to optical measurements (γ_k^m) and to smoothness constraints (γ_n^s). In this case γ_3^s corresponds to smoothness constraints on the imaginary part of refractive index.

6. The authors discuss AERONET measurements from many observational places scattered throughout the world. A table with geographical coordinates of these places would be very helpful. Please check if the name Mesaira is spelled correctly (Mesairaa?).

   Geographical coordinates are added. Mezaira is spelled correctly.

7. The authors analyze the improvement achieved with use of the 'new' smoothness constraints by comparing the wavelength dependence of the retrieved aerosol single scattering albedo (SSA) using the 'old' and 'new' version of the constraints. They consider the dependence of SSA on wavelength for different aerosol optical depth (AOD) bins. Fig. 1 shows SSA wavelength dependences for Rexburg and Rimrock observational places. Later, wavelength dependences of SSA are presented for AOD bins only for Rimrock (4), but not for Rexburg. Tables 1-3 present further analysis only for Rexburg, but not for Rimrock. The analysis should be done in uniform manner.

   The reasons of separating Rexburg and Rimrock data are the following. Rimrock AOD varies in wider range than that of Rexburg. Therefore, for plots presenting SSA retrievals averaged over AOD bins Rimrock was selected due to better sampling than in case of Rexburg statistics of SSA retrievals for both moderate (0.5-0.53) and high (1.0-1.4) AOD bins. For Rexburg there are just a few SSA retrievals corresponding to high AOD measurements. From other hand, overall statistics of aerosol retrievals for Rexburg is better than for Rimrock (it is just 18 retrievals total). That is why Rexburg was selected for comparison of STD-REL retrievals. In addition, the aerosol type which dominated the loading over Rexburg and Rimrock are similar: smoke from regional forest fires.

8. It is not clear how many observations are used to produce figures 1-11.

   There are two types of figures: individual cases (like Fig., 1) and retrievals averaged for AOD bins (like Fig. 4). For Figures of the second type the number of retrievals used in averaging is presented on figures.

9. Presence of error bars on the plots would simplify its understanding.

   Error bars in Version 3AERONET aerosol product are calculated for four standard channel retrievals. For the expanded set of wavelengths this is not currently done. They will be available in forthcoming Version 4.

10. Tables 1-3 show absolute differences between aerosol parameters retrieved using 'old' and 'new' constraints. I suggest including relative differences also because in many cases the absolute differences are too small and seeing so many zeros in the tables is not very informative.

    In fact, absolute differences are what is normally used to characterize uncertainty of aerosol retrievals. For example, in SSA case the 0.03 threshold is often used to determine the suitability of SSA retrievals for use in radiative forcing simulations. Relative differences are not so clearly interpreted. However, to facilitate the comparison, standard deviation was added to Tables 1-3.

11. The analysis presented in Tables 1-3 was done for wavelengths 440,675,870,1020 nm. Why is the 380 nm wavelength excluded from the analysis?

    Analysis was done for the four standard channel inversions to estimate the effect of using REL smoothness constraints on aerosol retrievals in Version 3. The 380 nm wavelength is not a part of AERONET standard inversion product yet.