

Reponses to the second reviewer's comments

We would like to thank this reviewer for the constructive comments. We have addressed the 6 specific comments and 30 technical comments as shown below.

Specific Comments and responses

C1. The paper concerns improving UV ozone profile retrievals which typically require some form of soft-calibration to account for errors in either the forward model, the measurements, or both. Were all soft-calibration corrections removed from the different retrievals before producing the results presented in figures 9 and 10? If not, how can the authors compare ozone profile retrievals from a mixture of RT configurations and soft-calibrations and attribute all differences to reductions in model approximation error? Presumably one expects the soft-calibration corrections for v2 should be smaller than v1. Is this the case?

R1. We have not applied the soft-calibration in this paper. In this paper, v1 and v2 stand for the ozone profile retrievals where all the implementations are same, but for the forward model simulations. Actually most implementations (ozone a priori, solar reference, slit function, meteorological input, and others) are updated in both v1 and v2 here compared to those applied for generating the PROFOZ product available via AVDC. Therefore, we should re-generate the soft spectra if we want to evaluate the impact of applying different forward model simulations on ozone profile retrievals with soft calibration. We are working on updating the soft spectra, but have not yet finalized. Therefore, soft-calibration was turned off in this paper, but those will be addressed in a companion paper.

C2. I suspect there is no mention of Ring effect in the paper because that is dealt with by the authors' retrieval. I think this should be mentioned at some point in the manuscript.

R2. Yes, the ring effect is modeled using a single scattering model (Sioris and Evans, 2000) and then is fitted as a pseudo absorber. Therefore, the ring simulation is independent of the PCA-based RT simulation, and is the same between v1 and v2. This paper is intended for discussing improvements (speed and accuracy) of ozone profile retrievals with newly implemented PCA-based RT simulation and LUT-based correction. The other implementation details were referred to Liu et al. (2010) where the SAO OMI algorithm was first presented, and the updates of those will be presented in companion paper.

C3. At line 272, I suspect authors don't truly mean their multiple-scattering radiance spectra are "To evaluate the performance of the PCA approximation, the "exact-RT" model is executed fully accurate," but rather these spectra represent the optimally configured model setup. If this is the case, please correct the wording.

R3. Yes. According to Fig. 3b, 12 full stream is used to perform accurate MS calculation as the remaining errors are within 0.01%. We have revised the indicated sentence to "To evaluate the PCA approximation, the "exact-RT" model is performed where accurate full-MS VLIDORT calculations are expensively performed at every wavelength in addition to accurate single scattering calculations.

C4. At line 418: will reducing errors in forward model approximations actually reduce random noise error? If that is the claim, what type of random noise errors are being referred to?

R4. "Random-noise errors" is misprint. We intended to say that the variabilities of individual differences are reduced. For clarification, the word, "random noise errors" has been changed to "the variabilities of individual differences"

C5. Is there an explanation for why the UV2 fitting residuals at low latitudes in figure 11 are somewhat larger for "PCA" than "VLD," but the reverse is true for UV1?

R5. We should be careful for evaluating the fitting residuals because the smaller fitting residuals could not directly lead to better ozone retrievals likely due to the presence of systematic measurement errors. As you indicated, using "PCA" results in slightly larger fitting residuals at low latitudes (Fig 11.e), but significantly improves the tropospheric column ozone retrievals at the entire latitude (Fig.11.b).

C6. The Evaluation and Summary and Conclusions sections need further editing. I suggest breaking the long

spans of text into shorter, more focused paragraphs, and reconsidering the amount of technical detail. For example, is it necessary to repeat the number of wavelengths on the OMI grid or the number of times the model is executed?

R6. Thanks for your constructive comment. We have carefully revised section 5.

Technical Comments and responses

C1. Line 49 – define LUT before using abbrev.

R1. Its abbreviation (Look Up Table) has been inserted.

C2. Line 62 – suggest using “and” or “with” rather than “+”

R2. Changed to “OMI and TES (Fu et al., 2013), OMI and AIRS (Fu et al., 2018), or GOME-2 and IASI (Cuesta et al., 2013)”

C3. Line 101 – change “work” to “perform.”

R3. The related sentence is “the PCA model is employed in this work”. We think that “work” should be kept as it is used as a noun.

C4. Line 107 – reword “less spectral sampling to “fewer spectral samples”

R4. This suggestion is accepted in the revised manuscript.

C5. Line 188 – remove “correspondingly”

R5. This suggestion is accepted in the revised manuscript.

C6. Line 126 – “atm” should not be superscript 126 – “for layer 0”

R6. $P_i = 2^{-\frac{i}{2}} atm$ has been revised to $P_i = 2^{-\frac{i}{2}}$ (in atm, 1 atm = 1013.25 hPa)

C7. Line 132 – what is an “effective wavelength”?

R7. For clarification, “effective” is deleted.

C8. Line 138 – note on VLIDORT 2.8 seems somewhat out of place. Can this be said earlier?

R8. To address this comment, we have put “The Vector Linearized Discrete Ordinate Radiative Transfer (VLIDORT) model v2.4 (Spurr et al., 2006) was employed as a forward model in the v1 OMI ozone profile algorithm (Liu et al., 2010) implemented at SIPS. We have updated VLIDORT to the latest version v2.8 for this study as well as in the PCA-VLIDORT described in Sect. 3. Note that there is little difference between v2.4 and v2.8 in term of simulation accuracy.” before “The simulation is iteratively...” in the first paragraph of Section 2.

C9. Line 145 – please indicate what ozone cross-sections were used.

R9. The related sentence has been revised as “at the sampling rate (0.01 nm) of the ozone cross sections (Brion et al., 1993)”

C10. Line 192 – is there a typo on the n+NN subscript on G? Also commas are missing between n and i subscript for delta and omega.

R10. $G_{n+N_N,i}$ has been corrected to $G_{n+N_L,i}$. The comma has been inserted between subscripts.

C11. Line 308 – the meaning of the subscript “on” is not defined in eqn. (11a).

R11. The subscript “on” indicates the on-line calculation, whereas the subscript “LUT” indicates the LUT-based calculation. For clarification, we have inserted “where the subscripts “on” and “LUT” stand for on-line and LUT-based calculations, respectively” before the equation 11.

C12. Line 313 – the naught subscript (0) is generally used for the solar angle, not the view angle. Is it

necessary to reverse this here?

R12. The manuscript has been revised to use the subscript 0 for solar zenith angle.

C13. Line 321 – does “based on” mean “at”?

R13. This suggestion has been accepted.

C14. Line 334 – Use of aq_1 suggests a product of two quantities, a and q_1 . It would be easier to C3 AMTD Interactive comment Printer-friendly version Discussion paper understand a single character representing this quantity. Same with aq_2 here and the qr term on line 334.

R14. According to this suggestion, we have changed the symbols aq_1 and aq_2 to k_1 and k_2 .

C15. Line 337 – I believe a minus sign is missing in front of eqn. (14c).

R15. the minus sign has been inserted.

C16. Line 359 – remove periods near the end of eqn. (17).

R16. Yes, this equation has been revised.

C17. Line 396 – change “significantly eliminated” to “significantly reduced” or just “eliminated.”

R17. It has been changed to “significantly reduced”.

C18. Line 411 change “in the highest” to “with the highest”

R18. It has been changed to “with the highest”

C19. Line 421 what is being compared to the “runtime” configuration here? ~

R19. This runtime represents the algorithm running time taken to retrieve individual pixels, which are evaluated with different forward models in Fig. 11.a. So the runtime of v_2 is compared to the runtime of v_1 here. For clarification, we changed the sentence to “the comparison of the runtime (Fig 11.a) demonstrates that v_2 is faster by a factor of 3.3 on average”

C20. Line 431 despite the very respectable in performance, the word “overcome” is a bit too strong. I feel an improvement speaks for itself.

R20. We agreed with that. “Overcome” has been changed to “improve”

C21. Line 441 change “correlated” to “in”

R21. This suggestion has been accepted.

C22. Line 442 replace “bins related” with “bins within”

R22. This suggestion has been accepted.

C23. Line 444 “. . .PCA approximation errors for our technique”

R23. We have edited them to “PCA approximation errors for our application”

C24. Line 455 what “OMI spectral fit” does is referred to here?

R24. This one represents the v_1 retrieval of OMI ozone profile, the associated sentence has been deleted during the revision.

C25. Line 588 what does the “List” column in Table 2 represent?

R25. It represents the order of bins. For clarification, it has been deleted.

C26. Line 604 in table 4, please abbreviate polarization correction as “pol. corr.” rather than “polcorr”.

R26. This suggestion has been accepted.

C27. Line 625 parentheses missing in the legend of figure 2.

R27. Thanks for your careful review, this figure has been revised.

C28. Line 640 please indicate what VZA and RAA are these calculations were made for?

R28. We have revised all captions to indicate viewing geometries performed for each testing.

C29. Line 684 typo: change “/” to “;” just before (e).

R29. “/” has been changed to “and”.

C30 Line 685 this figure would be more informative if the x-axis were latitude instead of along track number.

R30. This figure has been re-plotted in the axis based on the latitude.