Reponses to the first reviewer′s comments

We would like to thank this reviewer for the constructive comments. We have tried our best to address the 2 general comments, 4 specific comments, and 7 technical comments.

General Comments and responses

C 1. The improved fast RT calculation does improve the forward model accuracy, as a consequence, the ozone profile retrieval is improved, but it is unclear about the effect of errors in the previous radiative transfer calculation (as in Fig. 3) on the released ozone profile product, https://avdc.gsfc.nasa.gov/index.php?site=1620829979&id=74. There might be systematic error that varies with ozone profile and geometries (solar zenith, viewing zenith and relative azimuth angel), and thus depends on season, latitude and cross-track position. It is helpful to give a general assessment of these errors to data users.

R1. As commented, OMI ozone profile retrievals are significantly biased with respect to CCD dimensions (cross-track position, and wavelengths) as well as solar zenith angles. However, in this paper, we would like to confine the scope of this subject to retrieval errors caused by forward model simulation errors by comparing retrievals using the Reference configuration. But, we are in the preparation of another companion paper to evaluate the improved ozone retrievals with respect to forward model simulation as well as other updates, through comparison with global, long-term ozonesonde dataset. In this paper, we provided the evaluation results for three solar zenith angle regimes in Figure 9, showing that the large systematic errors of~ 5- 15 % due to v1 forward model errors are greatly eliminated below 30 km.

C2. The PCA-RT and LUTs considered the Rayleigh scattering atmosphere, however, for ozone profile retrieval, in the stratosphere the effect of scattering of aerosol is small or can be account for by fitting additional 1st or 2nd-order term of albedo or cloud fraction, but for tropospheric ozone, the effect of aerosol would be significant. What is the consideration about the scattering or absorption by particles (aerosol and optical thin cloud) in the model?

R2. The surface albedo is fitted as a first-order polynomial in UV2 (affecting tropospheric ozone retrieval) to partly account for aerosol effect and compensate for other scattering effects by clouds and surface. This seems to work reasonably well as we have not seen obvious retrieval artifacts in the presence of absorbing aerosols (e.g., Sahara dust). Our algorithm has option to include aerosols in the forward model simulation, using a mixture of six type of aerosols using monthly mean aerosol fields from model simulations. Previous tests have shown that whether to include aerosols does not significantly affect our retrievals. In addition, there are large uncertainties in aerosol optical depth inputs and it slows down the RTM (e.g., high number of streams). Therefore, we did not use this option in our retrievals.

Responses to Specific Comments

C1. The improved PCA-RT aims to simulate radiance to an accuracy better than 0.05%, to what extent, the ozone retrieval accuracy would be achieved?

R1. This criterion is determined to be better than measurement errors which are typically assumed

as the level of 0.1 % in the Huggins band for BUV measurements. In Figure 9, we can assess the effect of PCA-RT approximation errors (~ 0.05 % or less) on ozone retrieval errors (pink color: PCA^{1}), indicating the negligible effect above 10 km and the increasing errors up to ~ 1.5 % at the bottom layer.

C2. In section 3.1.2, each term of EOFs would relate to the specific optical properties of scattering and absorption in the atmosphere, please explain more about: what are the 1-3 EOFs relates to?
R2. Starting with a strongly-correlated set of optical property profiles, and working with logarithmic quantities, the PCA process first takes the spectral mean F_0 of the data, and then performs a PCA on the mean-removed set of (logarithmic) profiles. This yields a series of EOFs ranked in order of their contributions towards capturing the variance in the original data. The PCA reshuffles the optical data, such that the mean and the 1-3 most significant EOFs will provide a much smaller set of "super-profiles" that are used as inputs to the full multiple-scatter RT calculations. The distribution of scattering and absorption layer optical thickness values in the original profiles is replaced by a different set of distributions in the smaller set of "super profiles" which are constructed from the mean and the 1-3 EOFs. It is not really possible to put a physical interpretation on the EOFs (i.e. first mode is absorption, second scattering), but one could say that the first and most important EOF contains more information about the absorption profile, since it is the trace gas absorption that provides the bulk of the variability in the original data.

R3. One more concern is: it seems that only absorption of ozone is considered in the RT calculations, how about the effect of other trace gases like SO2, HCHO, and NO2? Do we need to apply more EOF if other gases are included, especially when there is large SO2 amount?
C3. The number of EOFs required in PCA simulation depends on the spectral variation of main absorber. In our application to ozone profile retrievals with 270-330 nm, the effect of other trace gases are really week compared to ozone absorption, therefore we don't need increasing the number of EOFs.

R4. Which model is used to generate LUT_H and LUT_L ? please make it clear in section 3.2.
C4. In section 3.2, it is addressed like "To construct LUTs, RT calculations are performed using the VLIDORT version 2.8 model"

Responses to Technical Corrections

C1. Line 124: better to use "converged" instead of "optimized"

R1. It has been corrected as "converged".

C2. In Fig.2b and 2c: legend (may be 0.05) in yellow are hard to see. Please change to other distinct color.
R2. This figure has been revised to make clear.

C3. Line 147: The sentence "around 310 nm if there is no error after undersampling correction to 0.05 nm." Is hard to understand, does it mean "around 310 nm and there is no error after undersampling correction is set to 0.05 nm."?

R3. For clarification, this sentence has been revised to “Fig. 2.b illustrates that LBL calculations are required to be performed at intervals of 0.03 nm or better.

C4. Line 180: “simulation” should be simulate
R4. The associated sentence is “the LUT-based correction is applied to simulation errors”. For clarification, we have corrected to “applied to approximation errors”

C5. Line 370: “Fig. c” should be Fig. 7c
R5. It has been corrected to Fig. 7c.

C6. Line 236： To be more clear, “the VLIDORT and FO Q/U values” should be “Q/U values calculated by VLIDORT and FO” .
R6. According to this comment, the relevant sentence has been revised as the differences of Q/U values calculated by VLIDORT and FO.

C7. In eq. 7 and 8, what does the ξ denote?
R7. ξ indicates the profile typed optical input, which has been added in the revised manuscript.