Response to Reviewer #1

Thank you for the reviewer's effort to review our manuscript. During the revision processes of our manuscript, we re-wrote most parts of the manuscript. In addition, we added results of sensitivity tests and error analysis for additional aerosol parameters. During the revision, we changed the radiative transfer model to improve the interface of previous model for surface albedo as well. For this reason, we also revised the methodology to explain the new radiative transfer model and its condition.

The manuscript describes an ambitious attempt to determine an aerosol effective height from a combination of OMI spectra and MODIS aerosol retrieval. The method, if it were to be improved to operational maturity, is of high interest to remote sensing and modeling communities in search of observational data on aerosol profiles. However, I see important obstacles on the road to practical application of this method, several of which are not or only barely addressed in the manuscript. In particular, these regard the choice of aerosol parameters (size, shape), possible mismatches between OMI and MODIS data, and cloud contamination of OMI data.

→ In addition to the revision, we added the sensitivity study of additional aerosol parameters as shown in Section 3.2. Section 3.2.1, 3.2.2, 3.2.4, and 3.2.5 respectively describes the sensitivity test of previously mentioned parameters, including AOD, SSA, surface albedo, and aerosol vertical distribution. In addition, Section 3.2.3 describes the result of sensitivity test for particle size. Please refer to this section for the details.
In addition, in the revised manuscript, the cloud contamination was carefully screened out by using cloud fraction less than 0.02, which is a strict threshold value for clear pixel selection. Because aerosol height retrieval is very challenging, we retrieved the aerosol height information over cloud free pixel only. For this reason, this study did not consider the cloud contamination of OMI data, although cloud is one of potential error source for aerosol height estimation.

In addition, the method is currently not described in sufficient detail; e.g., it remains unclear why MODIS AOD and type are used instead of OMI data, or why the DOAS fit of O4 is explicitly included in the AEH retrieval algorithm (when a look-up-table of air mass factors would appear to be sufficient: O4 has a broad absorption spectrum and fitting the SCD is relatively straightforward). As I noted in my review of the initial draft, there are too little references and comparisons to previous work (similar sensitivity studies have been performed by Veihelmann et al., 2007 and Wagner et al., 2010). The literature is cited in the introduction, but a summary of the previous findings and the relation to the current findings is missing from the manuscript.

→ In the revised manuscript, we added the details of method. For example, in Section 4, we described the reason to use MODIS AOD and type instead of those from OMI as below:

"Although OMI aerosol product provides AOD at 500 nm, AOD from OMI was partially affected by aerosol height and suffered from cloud contamination due to its large footprint (Torres et al., 2002). For this reason, AOD from MODIS allocated to the OMI pixels as a reference AOD for the AEH retrieval. For type selection, the AE from MODIS and AI from OMI is respectively used for the information of size and absorptivity, to classify aerosol type into four following the method from Kim et al. (2007) and Lee et al. (2007)."

Main reason of MODIS AOD selection is aerosol height dependence for OMI AOD. Furthermore, this study basically used the MODIS and OMI data for type selection. Therefore, we determined that selection of MODIS data for AOD is reasonable.

For directly comparison between our method and OMI standard product, we use SCD value for O4, although O4 has a broad absorption band and SCD fitting is relatively straight-forward. Details of algorithm flow are described in Figure 1 and 12 for model simulation and case study, respectively. In addition, details are explained in Section 2.1 and Section 4 for simulation and case study, respectively. Furthermore, we compensated the previous work from reviewer's suggestion in the introduction.

Lastly, and as mentioned in my review of the initial version, the presented case study does not provide convincing evidence that the algorithm works. First of all, only a single case is presented; second, CALIOP backscatter profiles are shown of which only a small part is detected by OMI (at 35-40 N, 122.5-123 E) — and these values do not agree very well (CALIOP doesn't exceed 1.7 km, whereas the retrieved AEH appears to vary from 1-5 km in this region). The comparison would have been more meaningful if AOD and aerosol type from CALIOP had been included, and a longer orbital segment had been selected. Third, as mentioned in the previous review, the comparison with ground-based lidar is not at all appropriate for reasons of collocation mismatch (the station is over land; the OMI measurement >100 km away and over ocean).

→ In Section 4, we described the AEH retrieval for two transported aerosol cases over East Asia. Furthermore, we also presented the scatterplot of AEH between CALIOP and OMI for 8 severe aerosol transport cases as listed in Table 8. Details are shown in Section 4 and Figs. 12 ~ 15.

In summary, I recommend that this paper be thoroughly revised before being resubmitted.

The most important revisions (addressed above) include:

- *More references and comparisons to literature*
- *Detailed, step-by-step description of the AEH algorithm in a separate section*
- *Assessment of additional error sources (wrong aerosol model assumptions; cloud*

contamination)

- Addition of more, and more appropriate case studies

Some suggestions for improvement of the paper are given below, but because in my opinion the manuscript requires extensive re-writing, more suggestions would follow in the next round of review.

→ We appreciate the reviewer's suggestion and comments to revise our paper. Basically we reflected all the comments and added all answers for the issues raised the revised manuscript. Reference and literatures are also added in Section 1 and 2. In Section 1, we revised as below with appropriate reference for example:

"The Differential Optical Absorption Spectroscopy (DOAS) technique has been used widely to retrieve trace gas concentration both from ground-based (e.g., Platt, 1994; Platt and Stutz, 2008) and space-borne (e.g., Wagner et al., 2007; Wagner *et al.*, 2010) measurements. After the work of Platt (1994) to retrieve trace gas concentration by using DOAS, Wagner et al. (2004) suggested to derive atmospheric aerosol information from O_4 measurement by using Multi Axis Differential Optical Absorption Spectroscopy (MAX-DOAS). Friess et al. (2006) analyzed the model studies to calculate the achievable precision of the aerosol optical depth and vertical profile. In addition, several studies (e.g., Irie *et al.*, 2009 and 2011; Lee *et al.*, 2009 and 2011; Clemer *et al.*, 2010; Li *et al.*, 2010) provided aerosol profiles from ground-based hyperspectral measurements in UV and visible wavelength ranges on several ground sites."

"For OMI measurement, the O_4 band at 477 nm has been widely applied to estimate cloud information (e.g., Accarreta et al., 2004; Sneep et al., 2008). Especially, the cloud information retrieved by O4 band at 477 nm was used for air mass factor (AMF) analysis with the consideration of aerosol optical effects for the NO2 column retrieval (e.g., Castellanos et al., 2015, Chimot et al., 2015; Lin et al., 2014; Lin et al., 2015). Although O4 absorption band around 477 nm varies also due to cloud existence, it can be also used for the aerosol optical parameter estimation. Veihelmann et al. (2007) introduced that the 477 nm channel, which locates major O4 band, significantly adds degree of freedom for aerosol retrieval by using principal component analysis, and Dirksen et al. (2009) adopts the pressure information obtained from OMI O4 band to identify a plume height for aerosol transport cases."

→ Detailed description of algorithm is added in Section 2 and 4 for model study and case study, respectively. In section 2.1, we revised the details of radiative transfer model regarding its change from LIDORT to VLIDORT.

"….the Linearlized pseudo-spherical vector discrete ordinate radiative transfer

(VLIDORT) model (Spurr, 2006). The VLIDORT model is based on the linearized discrete ordinate radiative transfer model (LIDORT) (Spurr et al., 2001; Spurr, 2002). This RTM is suitable for the off-nadir satellite viewing geometry of passive sensors since this model adopts the spherically curved atmosphere to reflect the pseudo-spherical direct-beam attenuation effect (Spurr *et al.*, 2001)."

→ Furthermore, we revised the assumption of aerosol vertical distribution for model input in the Section 2.1.2 as below:

"On the other hands, the aerosol vertical distribution does not always follow exponential profile. For the long-range transported aerosol such as dust cases, the aerosol layer profile is quite different than exponential profile and occasionally transported to well above the boundary layer (e.g., Reid et al., 2002; Johnson et al., 2008). The peak height of aerosol extinction profile in long-range transport cases was reported to be located between 1 and 3 km during the Dust and Biomass-burning Aerosol Experiment (DABEX) campaign (Johnson et al., 2008). From these previous studies, standard aerosol vertical profile is difficult to determine. For algorithm development, previous studies assumed that the vertical distribution is assumed to be Gaussian function defined by peak height and half width as representative parameters (Torres et al., 1998; Torres et al., 2005). To supplement the simplicity of assumption for aerosol vertical distribution, aerosol vertical distributions are assumed to be quasi-Gaussian generalized distribution function (GDF), which is Gaussian distribution with dependence on aerosol peak height, width, and layer top and bottom height. Details of GDF can be found in Spurr and Christi (2014) and Yang et al. (2010). In this study, AEH ranges from 1 to 5 km with 1 km width as 1-sigma for the RTM simulation."

→ We also revised the Section 2.2 for the step-by-step description of model simulation and clear-sky comparison test between modeled and observed O4 value. Because of large value of O4 SCD, we newly investigated the O4 Index as dividing O4 SCD by 10^{40} $\mathrm{molecule^2 cm^{-5}}$ which were also used in error studies in Section 3.2

"To estimate the error amount, the AEH error is converted from the half of O4I difference between adding and deducting perturbation of variables as shown in equation (1).

$$\varepsilon(Z) = \left| \frac{\mathrm{O4I}(x+\delta x, Z) - \mathrm{O4I}(x-\delta x, Z)}{2.0 \times d\mathrm{O4I}/dZ(x, Z)} \right| \quad (1)$$

where $\varepsilon(Z)$ is the AEH error amount due to variable of error source, x, in AEH of Z, and δx is perturbation of AEH retrieval error source. The $\varepsilon(Z)$ value also depends on viewing geometries. Therefore $\varepsilon(Z)$ is represented for specific geometries together with averaging over all geometries."

→ For the details of case study, we revised the algorithm flowchart in Figure 12 in the revised manuscript, and added the details as below:

"Figure 12 describes an AEH retrieval algorithm for the case study. In retrieving AEH, AOD is obtained from MODIS standard product (e.g., Levy et al., 2007). Although OMI aerosol product provides AOD at 500 nm, AOD from OMI was partially affected by aerosol height and suffered from cloud contamination due to its large footprint (Torres et al., 2002). For this reason, AOD from MODIS allocated to the OMI pixels as a reference AOD for the AEH retrieval. For type selection, the AE from MODIS and AI from OMI is respectively used for the information of size and absorptivity, to classify aerosol type into four following the method from Kim et al. (2007) and Lee et al. (2007). After determining AOD and aerosol type, LUT, which is generated as functions of geometries (SZA, VZA, and RAA), aerosol types and AODs, is used to determine the AEH information by using comparison between simulated and measured O4I value. The variables and their dimensions for the LUT calculations are shown in Table 7. Due to the limitation of the accuracy of aerosol type classification and those of AOD over land, this study estimates the AEH only over ocean surface. Although temporal and spatial variation of surface albedo influences the AEH result from error study, surface albedo is assumed to be a fixed value of 0.10, which is used in sensitivity study. For case study, the LUT of O4I is developed by the aerosol model based on AERONET data over East Asia. Extensive AERONET dataset over East Asia are used to provide represent aerosol optical properties for the LUT calculation."

→ In section 3, we showed the result of sensitivity test for additional error sources of aerosol parameters, especially aerosol particle size in Section 3.2.3. Furthermore, AEH sensitivity showed the result with changing viewing geometries in Figure 8. Finally, case study results are also added in Section 4. In detail, we described one additional specific scene result in Figure 14 in the revised manuscript. Details are shown as below:

"Figure 14 is another case study of the retrieved AEH on February, 21, 2008. MODIS products of AOD and FMF on this date show thick anthropogenic aerosol transported with the AOD ranging from 0.6 to 1.0 [Figure 14(b)] and the FMF ranging from 0.8 to 1.0 [Figure 14(c)] all over Yellow sea. The mean retrieved AEH is 1.4±1.2 km over 1480 pixels in East Asia as shown in Figure 14(d). On this date, CALIOP passed over coastal line between China and Yellow Sea. The aerosol layer height ranged from 0.5 to 2.5 km during the overpass over East Asia as shown in Figure 14(e). The AEH from OMI is 0.6±0.4 km over 601 pixels in 30~40 ˚N and 120~125 ˚E. Contrary to large spatial variation of the AEH from CALIOP, the AEH from OMI shows spatially stable values on this date."

→ Furthermore, we showed direct comparison test between CALIOP and OMI for 2-

year transported aerosol cases over East Asia. The results are shown in Figure 15 in the revised manuscript with the list of cases in Table 8 in the revised manuscript. Details are explained as below:

"Figure 15 shows the scatter plot of AEH between CALIOP and OMI on the date listed in Table 8, which lists aerosol transport cases over East Asia with simultaneous observations by OMI and CALIOP in 2007 and 2008. Because the O4I sensitivity for AEH is not large at AEH higher than 4 km, the comparison test was limited to cases with AEH less than 4.5 km from OMI. For data collocation, the latitude and longitude difference between two sensors are within 0.25 degree. Figure 15(a) shows the comparison of AEH from OMI and CALIOP with MODIS AOD larger than 0.5. It is assumed that the reference expected error (EE) is 1 km (Fishman et al., 2012). Almost 60% of retrieved pixel shows the AEH result within the EE. Because of large AEH error for low AOD, the accuracy of AEH result from OMI is poor. Furthermore, this case study assumes constant surface albedo value over ocean. However, ocean surface albedo is also changed by turbidity due to sediments and wind. For this reason, the AEH error is enlarged for low AOD cases. If threshold of AOD for the comparison is set to be 1.0, the proportion of pixel within EE improves up to 80% as shown in Figure 15(b). Furthermore, the correlation of the AEH between the two sensors is 0.62 as a slope with 0.65 of correlation coefficient (R) on thick aerosol layer cases. Therefore, the AEH algorithm from OMI provides the reasonable information about the parameter of aerosol vertical distribution, if accurate aerosol model is provided for forward calculation."

During the revision, the manuscript reflected all other comments as shown below.

Other comments

P.7934, ll. 11-14: "Overall, the error (...) vertical distribution type." Mention that the cited error values apply to the base case (SZA=30, VZA=30; I was unable to find the reference AOD and AEH). More importantly, the overall error here does not include the uncertainty due to vertical distribution. Although this is mentioned in the quoted sentence, it does not appear to be fair to leave out this major error contribution — particularly because its magnitude was explicitly determined.

In the revised manuscript, the error analysis for aerosol vertical distribution was changed as shown in Section 3.2.5. We estimated errors using all viewing geometries, AOD and AEH as shown in Table 3 in the revised manuscript. Because aerosol vertical distribution cannot estimate high-resolution information, the error budget for aerosol vertical distribution is summarized in Table 5 in the revised manuscript.

P. 7935, ll.15ff: "The information on the aerosol height is important (...)" Also for the improvement of trace gas retrievals (better air mass factor calculation) the aerosol profile is of importance.

We reflect the comment in the revised manuscript as below:
"The information on the aerosol layer height is important, because the variation of the aerosol vertical distribution affects radiative process in the atmosphere near the surface and trace gas retrieval for air mass factor calculation."

P. 7936, l.8: "(Wagner et al., 2010)" This reference is not appropriate, better would be, e.g: Wagner, et al., 2008, doi: 10.1088/1464-4258/10/10/1040192008), but there are many others, too.
P. 7936, ll.8-28: "Recently, several studies (...) aerosol transport cases." The results from the cited studies need to be summarized and discussed in more detail, probably in a separate section. The findings from those previous studies should be used as starting points for your own studies, and you should explain what your own studies add to the existing body of knowledge.

We reflect the comment in the revised manuscript as below:
"The Differential Optical Absorption Spectroscopy (DOAS) technique has been used widely to retrieve trace gas concentration both from ground-based (e.g., Platt, 1994; Platt and Stutz, 2008) and space-borne (e.g., Wagner et al., 2007; Wagner *et al.*, 2010) measurements. After the work of Platt (1994) to retrieve trace gas concentration by using DOAS, Wagner et al. (2004) suggested to derive atmospheric aerosol information from O_4 measurement by using Multi Axis Differential Optical Absorption

Spectroscopy (MAX-DOAS). Friess et al. (2006) analyzed the model studies to calculate the achievable precision of the aerosol optical depth and vertical profile. In addition, several studies (e.g., Irie *et al.*, 2009 and 2011; Lee *et al.*, 2009 and 2011; Clemer *et al.*, 2010; Li *et al.*, 2010) provided aerosol profiles from ground-based hyperspectral measurements in UV and visible wavelength ranges on several ground sites. Wagner *et al.* (2010) investigated the sensitivity of various factors to the aerosol layer height using the data obtained from the SCanning Imaging Absorption SpectroMeter for Atmospheric ChartographY (SCIAMACHY) on ENVISAT. The sensitivity of the Ring effect and the absorption by oxygen molecule (O_2) and its dimer (O_4) calculated by DOAS method were examined to estimate aerosol properties including the layer height. Kokhanovsky and Rozanov (2010) estimated dust altitudes using the O_2-A band between 760 and 765 nm after the determination of the dust optical depth. In addition, several previous studies are also investigated estimation methods for aerosol height information by using hyperspectral measurement in visible (e.g., Dubuisson *et al.*, 2009; Koppers and Murtagh, 1997; Sanders and de Haan, 2013; Sanghavi *et al.*, 2012; Wang *et al.*, 2012). Because in the near UV the surface signal is significantly smaller than the aerosol signal, the UV and near UV regions are useful to derive aerosol height information from space borne measurements."

P.7937, l.10: The term SCD is not explained. I think some DOAS theory, or at least a discussion of radiative transport, is needed in this section. I strongly encourage the use of AMFs instead of SCDs, because the numbers are more intuitive. Apart from that, since the O4 VCD is well known, it might as well be removed (i.e., divided out) for simplicity.

To supplement the DOAS theory and to explain the disadvantage of directly used O4 SCD value, we revised the manuscript as below:

"Figure 1 shows the flowchart of the method to estimate the O_4 SCD from the simulated radiance. Because the magnitude of the O_4 SCD values is too large to express the sensitivity results, this paper defines the O_4 index (O4I) which divides O_4 SCD by 10^{40} molecules^{2}cm^{-5}."

P. 7940, l.19: "the noise level" Where does the (relatively large) noise in the simulations come from?

Although cross section database are identified, the noise from fitting residual is estimated during DOAS fitting from simulated radiance because DOAS fitting is independently tested.

P. 7940, l.22- P.7941, l.19: "Figure 2 shows the comparison (...) to retrieve aerosol height." This section raises some issues, e.g.: how do the data look for AOD=0? An AOD of 0.15 appears rather high, although this might account for occasional cloud contamination of OMI data. The correlation is good, but not perfect, and it would be *interesting to know if there are systematic deviations (e.g., for certain solar/viewing geometries). I would expect some deviations, particularly at larger viewing angles, simply due to the coarse resolution of the LUT (at the swath edges SCD probably depends strongly on viewing angle). The fact that the O4 cross section needs scaling for a better agreement of results is attributable to the difference in cross-sections used by the authors on the one hand, and the OMICLDO2 retrieval team on the other hand.*

We revised the clear-sky comparison test in Section 2.2, and Figure 2 and 3 in the revised manuscript.

P. 7942, l.21: I would rename this section to, e.g., "Sensitivity of O4 SCDs at various wavelengths to AEH", and then add another section, e.g. "Sensitivity of 477nm O4 SCDs to various aerosol parameters" at page 7944, line 4 to improve readability. This is the section where a comparison with previous sensitivity studies should be presented.

→ After revision this sentence is deleted.

P. 7942, ll.4-6: "However, the absorbing aerosols in low AEH cases (...) and 380 nm." What do you mean by "fluctuated" ? And what is the cause of the large fitting error?

→ After revision this sentence is deleted.

P. 7942, ll.6-8: "For this reason (...) in the AEH range of 2.0 to 4.0 km." This is a quite clear definition of -dO4/dZ, but in the next lines, you often use a different definition, e.g. in lines 9-10 on the same page. This appears to be the maximum -dO4/dZ for a certain altitude, which is not in agreement with the definition cited above and confuses the reader.

→ After revision this sentence is deleted and more detailed analysis is added in Figs. 4-5.

P. 7942-7943: The results in this section should be presented in a more clear and concise way. In fact, they can be summarized (somewhat crudely) by simply saying that O4 absorption features at wavelengths other than 477 are not suitable for AEH retrieval because the sensitivity of the O4 SCD to AEH is smaller than or comparable to the fitting error.

→ We revised in the revised manuscript as below:

"The O4Is are estimated at 360 and 380 nm band as shown in Figure 4(a) ~ (f). The O4I is significantly decreased with increasing AEH at 360 and 380 nm for all aerosol types. However negative O4Is are occasionally estimated at 360 nm. Furthermore the fitting errors are too large to estimate the AEH, which range from 160 to 410 at 360 nm and from 350 to 1060 at 380 nm. From large fitting error with small O4I, the fitting results are insignificant at these two absorption bands."

P. 7944, ll.13-14: "Torres et al., (...) due to the cloud contamination." This is not very *relevant to the current study, as no OMI aerosol data are used.*

P. 7944, ll.14-15: "SSA varies widely as the categorizing aerosol types." Do you mean: SSA varies widely for different aerosol types?

→ To clarify the SSA error test we revised on Section 3.3 in the manuscript as below:

"The mean errors from 10% variation in the SSA for all of the variable conditions in Table 3 correspond to 726, 576, and 1047 m for the MITR, COPO, and WASO, respectively. For the total error budget calculations, however, 5% change in the SSA was used according to Torres *et al.* (2007), which reported the variation of the SSA less than 0.03 for the given aerosol type. The error from the vertical distribution is estimated to be 720, 1480, and 690 m for the COPO, MITR and WASO, respectively.

The errors from the SSA and the aerosol profile shape are the two important error sources in estimating the AEH, followed by the errors related to the AOD and the surface albedo. From these results, the errors of the AEH due to the error from OMI AOD of 0.1 and the surface albedo of 0.02 are less than 300 m for WASO and COPO, and about 400 m for MITR. However, the AEH error from surface albedo is important for cases with low AOD at high AEH, which is surface reflectance dominant case."

P. 7945, Sect. 3.2: Discuss uncertainties arising from errors in assumed particle size and shape (phase functions). Also missing is the uncertainty due to mis-classification of aerosols (e.g., COPO as WASO). Cases with more than one layer of aerosols also deserve attention here.

→ We added the Section 3.2.3 in the revised manuscript. In this study, aerosol vertical distribution also concerned to be error source. However mis-classification of aerosol types and cases with more than one layer of aerosols are difficult to identify the parameter for aerosol vertical information.

We mentioned in the revised manuscript as below:

"Although this study is not able to show all kinds of aerosol vertical distributions due to its large variability in profile, aerosol vertical distribution by changing the half-width of GDF distribution can reflect large-scale changes in its vertical profile."

P. 7947, ll.6ff: Large parts of this section, particularly the description of the OMI instrument and the description of the AEH derivation algorithm, should be put into a separate Methods section. The section should also contain an explanation of how MODIS data are selected and integrated into the AEH algorithm.

→ We revised the method of AEH algorithm and data selection for case study in the beginning of Section 4 in the revised manuscript as below:

"To demonstrate the feasibility from real measurements, the AEHs are derived using hyperspectral data from OMI. OMI channels are composed of UV-1 (270-314 nm), UV-2 (306-380 nm), and a visible wavelength range (365-500 nm) with a spectral resolution (FWHM) of 0.63, 0.42, and 0.63 nm, respectively (Levelt *et al.*, 2006). The spatial resolution is 13 km × 24 km at nadir in "Global Mode". In the present study, the spectral data over the visible wavelength range are used to derive the O4I at 477 nm and the AEH information.

Figure 12 describes an AEH retrieval algorithm for the case study. In retrieving AEH, AOD is obtained from MODIS standard product (e.g., Levy et al., 2007). Although OMI aerosol product provides AOD at 500 nm, AOD from OMI was partially affected by aerosol height and suffered from cloud contamination due to its large footprint (Torres et al., 2002). For this reason, AOD from MODIS allocated to the OMI pixels as a reference AOD for the AEH retrieval. For type selection, the AE from MODIS and AI from OMI is respectively used for the information of size and absorptivity, to classify aerosol type into four following the method from Kim et al. (2007) and Lee et al. (2007). After determining AOD and aerosol type, LUT, which is generated as functions of geometries (SZA, VZA, and RAA), aerosol types and AODs, is used to determine the AEH information by using comparison between simulated and measured O4I value. The variables and their dimensions for the LUT calculations are shown in Table 7. Due to the limitation of the accuracy of aerosol type classification and those of AOD over land, this study estimates the AEH only over ocean surface. Although temporal and spatial variation of surface albedo influences the AEH result from error study, surface albedo is assumed to be a fixed value of 0.10, which is used in sensitivity study. For case study, the LUT of O4I is developed by the aerosol model based on AERONET data over East Asia. Extensive AERONET dataset over East Asia are used to provide represent aerosol optical properties for the LUT calculation."

P. 7948, ll.12-13: "From CALIOP observation, . . . for most observed regions." What about the small region that is collocated with the OMI/MODIS measurement?

→ In the revised manuscript, we compared the AEH from OMI and CALIOP AEH within 0.25 degree for latitude and longitude of GSD, and we showed the result in Figure 15.

P. 7948, ll.25-26: "the investigated algorithm quantitatively estimates the AEH over East Asia." This statement is rather too bold (as mentioned previously). You have not proven this with the one case study presented in the manuscript.

→ We added two cases for scene analysis and direct comparison result between CALIOP and OMI in several cases from 2007 to 2008 over East Asia as shown in Figs. 13-15 in the revised manuscript.

P. 7949, Sect. 5: Add the error from profile shape assumptions to the total error; this would appear to be more fair.

PP. 7963-7964: Why not merge Tables 6 and 7?

→ Because the error from aerosol profile shape assumption is relatively large, we separately showed the result in Table 5.

Fig. 3 : the lower panel is wrong; it shows results for 360 nm instead of 340 nm

→ We revised in the revised manuscript.

Figs. 3-6: Add the Rayleigh AMF (more informative than the geometrical AMF); it is given in Fig. 7 for 477 nm (at AOD=0).

→ We revised in the revised manuscript as converting O4 index value.

Fig. 9a: What is the cause of the red color?

Fig. 9e: Add the CALIOP ground track.

→ We revised the Figs. 13 and 14 in the revised manuscript as removing ground LIDAR results, because ground LIDAR site is too far to compare directly. Because CALIOP ground track addition would be confusing to show the scene result, we mentioned the sentences to explain the track information for respective case study as below:

"The retrieved result is compared with the backscattering intensity from the CALIOP observation over Yellow sea as shown in Figure 13(e). From CALIOP observation, the aerosol layer height over Yellow sea is located around 1 km altitude for most observed regions."

"On this date, CALIOP passed over coastal line between China and Yellow Sea. The aerosol layer height ranged from 0.5 to 2.5 km during the overpass over East Asia as shown in Figure 14(e)."