We thank the reviewer for the comments and suggestions. We realize the importance to add comparison between constructed AVS from satellites to ground-based lidar measurements. We have refined our analysis and made changes to address other questions.

We thank reviewer's understanding of the difficulty of evaluating the AVS retrieval due to scarcity of AVS measurements, and we made our best effort to find measurements we were able to compare with.

We found the Asian dust and aerosol lidar observation network (AD-Net) when we looked for ground-based lidar stations with freely downloadable data. AD-Net is a lidar network for continuous observations of vertical distributions of Asian dust and other aerosols in East Asia. The sites contribute to the WMO GAW Program, and form the East Asian component of the GAW Aerosol Lidar Observation Network (GALION). Although cooperative stations in China didn't provide data sharing, we found some data that we were able to compare at Seoul station (37.5N,127.0E).

Seoul station has a standard lidar system in AD-Net, which is a two-wavelength (1064 nm, 532 nm) polarization sensitive (532 nm) Mie-scattering lidar, plus a 532 nm Raman (Shimizu et al. 2004). Based on the ground track, the A-Train sensors made overpass near the station for a total of 6 days during our case study in spring 2015. However, 4 out of these 6 days were heavily cloudy. For the remaining 2 days, March 7th and April 24th, the comparisons among ground-based lidar profiles, CALIPSO profiles at shortest distance and RXS-expand profiles averaged 25 km around the location of Seoul station are shown in the following figure.

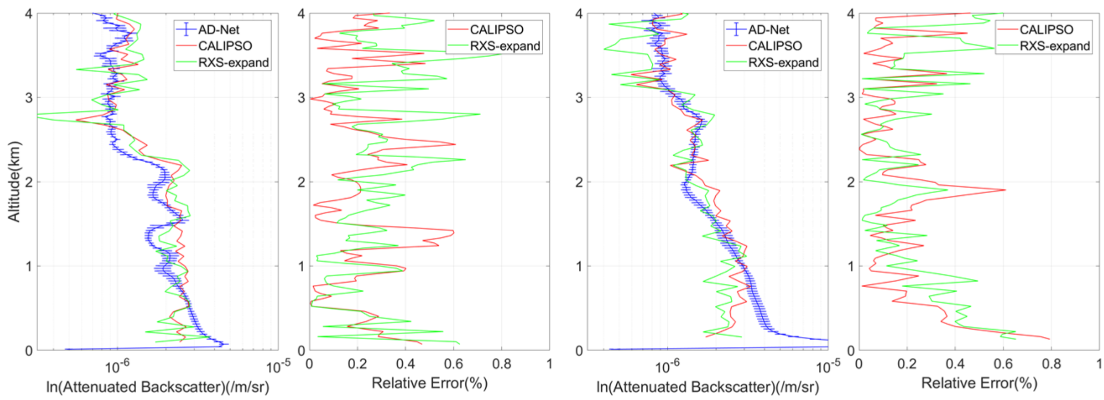

Figure 1 Comparisons among ground-based lidar profiles of 532 nm attenuated backscatter coefficient products (units: $m^{-1}sr^{-1}$, averaged 2 hour within satellite overpass), CALIPSO profiles at shortest distance and RXS-expand profile averaged 25 km around the location of Seoul station. The two plots on the left are from March 7th, 2015, and the two plots on the right are from April 24th, 2015.

The CALIPSO measurements we used for comparisons are level 1.5 data product of attenuated backscatter profiles, which clouds, overcast, surface, subsurface, and totally attenuated samples have been removed before being averaged to a 20 km horizontal resolution. In this case, RXS-expand profiles are based on the same products. The ground-based measurements used for comparison are the 532 nm attenuated backscatter coefficient products, averaged within 2 hr before and after the satellite overpass with 15 min time resolution.

For the aerosol layer 0-4km above the ground, the relative error between CALIPSO profiles and ground station profiles are on average 21.6% on March 7^{th}, and 18.7% on April 24^{th}. The distances between station and ground track are 51.0 km on the first day, and 50.1 km on the second. Between RXS-expand profiles and ground station profiles, the average relative error is 27.9% and 23.4%, respectively.

The results from the comparisons agreed in general. First of all, there were considerable disagreement between CALIPSO measurements and ground-based lidar measurements; in most studies, the differences were found to be around 20% (Mamouri et al. 2009, Wu et al. 2011, Kim et al. 2008, Chiang et al. 2011). For example, Mamouri et al. (2009) compared CALIPSO attenuated backscatter coefficient profiles with a ground-based lidar in Athens, Greece, and they found the agreement on the order of −10±12% for cloud-free daytime measurements between 3 and 10 km, while the differences between 1 and 3 km were much larger (−34±34%). In addition, we want to clarify that we did not intend to get a precise quantification of aerosol profile through the scene construction method. After all, the active pixel being matched to the passive column is intended only to provide an estimate of the column's vertical structure. We did expect, to some extent, the estimation could be improved through calculations with constrains such as the column AOD measured by passive sensor at the exact location of the recipient pixel, which will need a lot more work in the future.

As for reviewer's more specific comments, we made following changes to the content in the context and figures.

Page 2, lines 1-23. I'm surprised not to see any mention here of ground-based lidar networks, which are sometimes used in combination with CALIOP data; or of the shorter-lived NASA CATS lidar that was aboard the ISS.

We thank the author for the suggestion and we plan to add the following lines to the content, as a separate paragraph after the first one on that page.

"The development of Lidar technology helped provide these vital missing piece of information. Ground-based lidar systems have been stationed at various locations and also used in field campaigns to measure the vertical and horizontal distribution of aerosols (Welton et al. 2000, Welton et al. 2002, Badarinath et al. 2010). Ground-based lidars provide measurements on the fixed locations on timescale of minutes to hours, depending on the specific type of lidar used in the experiment. Limited by the stationary setting, ground-based lidars could not achieve true global coverage, nevertheless, network of ground-based lidars (e.g. MPL-NET, EARLINET, AD-NET) provide key insights to atmospheric study and are involved in validation of satellite sensors (Kovacs et al. 2004, Mamouri et al. 2009, Pappalardo et al. 2010)."

Page 6, lines 18-21. These cloud cover rates seem very low. For passive sensors, 70% is a reasonable ballpark estimate for the fraction of the globe covered by clouds at any given time. Most such clouds would occupy only a small part of the vertical column (and as the paper states, almost never at high altitudes) but the numbers still seem difficult to reconcile. Have you calculated the global cloud cover from the column perspective, for comparison?

We thank the author for the question and comment. We will make it more clear in the revision that the numbers in Table.2 refers to cloud occurrence as percentage they occupied in the vertical column. We calculated this occurrence rate according to CALIPSO VFM products, which was scaled for vertical and horizontal resolution (Hunt et al. 2009). However, it is true that the numbers in the table underestimated the amount of clouds in actual atmosphere. As we stated, CALIPSO's signal can be totally attenuated beneath clouds and possibly making cloud layers below showed up as "no signal". The horizontal cloud coverage between 60°N and 60°S for the tested periods in April and September 2015 are 68.7% and 71.3%, respectively.

Page 6, Figure 2. This is fascinating. It would be interesting to see a more detailed discussion of the contrast between 0-2 km and 2-4 km, which appear to distinguish local aerosol from aerosol undergoing long-range transport.

We thank the author for the suggestion. We add more discussion about the contrast between 0-2 km and 2-4 km into the last paragraph on page 6. The paragraph is modified as following:

"Height-resolved global AOD maps (averaged for a 2°×2° lat/long grid) based on the two selected periods are shown in Fig.2. In the near-surface layer, 2 km above ground level (AGL), in April, relatively high aerosol loadings are found in the cross-Atlantic African dust transport, Saudi Arabia, and India. In September, dust dynamics are much weaker but much biomass burning is apparent in the Brazilian Amazon and Southern Africa. This seasonal trend of dust and smoke is more obvious in the layer 2-4 km AGL. Aerosol in this layer aloft are expected to be undergoing long-range transport. In April, the thickest dust layers are found slightly inland of the western coast of Africa, around 12.5°N, 5.5°E, and in the center of Saudi Arabia around 24.5°N, 42.5°E. The shift of AOD distribution between surface layer and layer above is logical, and indicates the movement of dust layers as the aerosol loadings are transported towards the oceans. In September, this contrast is harder to observe as the dust dynamic is weaker, but similar trends are found in the biomass burning regions. In addition, persistent high aerosol loadings in both 0-2 km and 2-4 km AGL are found in India and the east coast of China with mixed sources of natural aerosols and pollutants. The results could be affected by the local topography. Marine aerosols are confined largely to the near-surface layer, with some vertical transport in Southeast Asia in September due to the Asian monsoon. The observed pattern is mostly consistent with other studies in terms of global distribution and seasonal variations (Martins et al., 2018;Liu et al., 2012;Chen et al., 2018)."

Page 8, Figure 3. This plot is somewhat difficult to read. A different color scheme may make the drop in the matching rate at the ITCZ easier to spot, but

I'm having trouble seeing any other patterns.

We agree with the reviewer that Figure.3 is rather vague for the information we tried to convey. In fact, we think Figure.3 does not give enough extra information on its own, other than these results given in Figure.4. Therefore, we make a decision to remove this figure.

Technical comments:

Page 6, line 14. "Losing".

Page 8, line 19. "CALIOP profiles".

We thank the author for the comment, and these lines will be changed as suggested.

"From 10 - 24 April and 14 - 29 September, CALIPSO functioned normally except during a boresight diagnostic and alignment on 18 September, losing about half of that day's data."

"With the complete datasets of CALIPO profiles, MODIS radiances and geolocation fields, construction based on the SRM method can be applied worldwide."

Badarinath, K. V. S., S. K. Kharol, D. G. Kaskaoutis, A. R. Sharma, V. Ramaswamy & H. D. Kambezidis (2010) Long-range transport of dust aerosols over the Arabian Sea and Indian region A case study using satellite data and ground-based measurements. *Global and Planetary Change,* 72**,** 164-181.

Chiang, C.-W., S. K. Das, Y.-F. Shih, H.-S. Liao & J.-B. Nee (2011) Comparison of CALIPSO and ground-based lidar profiles over Chung-Li, Taiwan. *Journal of Quantitative Spectroscopy & Radiative Transfer,* 112**,** 197-203.

Hunt, W. H., D. M. Winker, M. A. Vaughan, K. A. Powell, P. L. Lucker & C. Weimer (2009) CALIPSO Lidar Description and Performance Assessment. *Journal of Atmospheric and Oceanic Technology,* 26**,** 1214-1228.

Kim, S. W., S. Berthier, J. C. Raut, P. Chazette, F. Dulac & S. C. Yoon (2008) Validation of aerosol and cloud layer structures from the space-borne lidar CALIOP using a ground-based lidar in Seoul, Korea. *Atmospheric Chemistry and Physics,* 8**,** 3705-3720.

Kovacs, T. A., M. P. McCormick, C. R. Trepte, D. M. Winker, A. Garnier & J. Pelon. 2004. Coordination of quid pro quo ground-based measurements of cloud and aerosol optical properties for validation of the CALIPSO mission. In *Conference on Lidar Remote Sensing for Industry and Environmental Monitoring V*, 281-289. Honolulu, HI.

Mamouri, R. E., V. Amiridis, A. Papayannis, E. Giannakaki, G. Tsaknakis & D. S. Balis (2009) Validation of CALIPSO space-borne-derived attenuated backscatter coefficient profiles using a ground-based lidar in Athens, Greece. *Atmospheric Measurement Techniques,* 2**,** 513-522.

Pappalardo, G., U. Wandinger, L. Mona, A. Hiebsch, I. Mattis, A. Amodeo, A. Ansmann, P. Seifert, H. Linne, A. Apituley, L. Alados Arboledas, D. Balis, A. Chaikovsky, G. D'Amico, F. De Tomasi, V. Freudenthaler, E. Giannakaki, A. Giunta, I. Grigorov, M. Iarlori, F. Madonna, R. E. Mamouri, L. Nasti, A. Papayannis, A. Pietruczuk, M. Pujadas, V. Rizi, F. Rocadenbosch, F. Russo, F. Schnell, N. Spinelli, X. Wang & M. Wiegner (2010) EARLINET correlative measurements for CALIPSO: First intercomparison results. *Journal of Geophysical*

Research-Atmospheres, 115.

Shimizu, A., N. Sugimoto, I. Matsui, K. Arao, I. Uno, T. Murayama, N. Kagawa, K. Aoki, A. Uchiyama & A. Yamazaki (2004) Continuous observations of Asian dust and other aerosols by polarization lidars in China and Japan during ACE-Asia. *Journal of Geophysical Research-Atmospheres,* 109.

Welton, E. J., K. J. Voss, H. R. Gordon, H. Maring, A. Smirnov, B. Holben, B. Schmid, J. M. Livingston, P. B. Russell, P. A. Durkee, P. Formenti & M. O. Andreae (2000) Ground-based lidar measurements of aerosols during ACE-2: instrument description, results, and comparisons with other ground-based and airborne measurements. *Tellus Series B-Chemical and Physical Meteorology,* 52**,** 636-651.

Welton, E. J., K. J. Voss, P. K. Quinn, P. J. Flatau, K. Markowicz, J. R. Campbell, J. D. Spinhirne, H. R. Gordon & J. E. Johnson (2002) Measurements of aerosol vertical profiles and optical properties during INDOEX 1999 using micropulse lidars. *Journal of Geophysical Research-Atmospheres,* 107.

Wu, D., Z. Wang, B. Wang, J. Zhou & Y. Wang (2011) CALIPSO validation using ground-based lidar in Hefei (31.9A degrees N, 117.2A degrees E), China. *Applied Physics B-Lasers and Optics,* 102**,** 185-195.