We would like to thank the Reviewer for his/her thorough and detailed review as well as for the suggested papers. Our responses (in blue) for each comment (in black) are provided below.

[updates in the algorithm]

Lowered the retrieval cutoff AHI AOD from 0.6 to 0.3.

Removed 10 km ATH cutoff.

Image-matching is no more conducted when 20 % of the pixels in moving (or, reference) window is cloud-contaminated.

[changes in figures]

Figures use updated version of ATH.

CALIOP L2 aerosol extinction profile is replaced to CALIOP L1 total attenuated backscatter in Fig.6 (e) and Fig. 7 (e).

Fig. 8 is replaced with 2-dimensional histogram.

Added x=0 line in Fig. 9.

Changed colormaps in Fig. 10 to the same colormap of Fig.6 and Fig.7.

Wrong figure in Fig. 10 (d) is replaced.; discussion in the manuscript is also changed.; Lines399-401.

Summary: This paper explores the utility of stereoscopic methods from geostationary satellites to make an aerosol plume height estimate. With the advent of next generation imagers over Asia (GK-2A; Himiwari-8, FY-4 etc.), North/South America (GOES 16, 17, and now 18), and now starting in Europe (MTG), there is great potential in combining data in overlap zones. This work is one of several in recent years trying to make use of this new capability. Here, the authors provide a relative brief paper on their experiments combining AHI with AMI and AGRI to derive aerosol heights for cases around the Korean Peninsula. The paper briefly gives a rationale for the work, a list of data sources, explication of geometry, and finally performs comparisons to CALIOP and the Korean Lidar Network. As one would expect, skill is favored by geometries with wider separation between instruments.

After reading the paper, it was not clear to me how well the products actually work. In concept (as the authors note) there are fundamental differences in what is produced between spectroscopic aerosol height methods (say OA&B based TROPOMI based) and stereographic assessment (e.g. MISR). Spectroscopic methods give a centroid height, and stereographic give a feature height. The way the paper is laid out, it is not clear what specific features are being keyed off on in the algorithm. For clouds it can be straightforward, for aerosol features uncles there is a dense plume there are multiple textures in the satellite imagery. There is no discussion on this, and other assumptions such as the presence of embedded clouds they admitted they ignored. Looking at the scatter plots, there is so much scatter I am not sure their algorithm beats a climatology. E.g., if one takes the average of the average of CALIOP heights, does the retrieval's RMSD beat that? And if so by how much? It would not surprise me that there is a bias, but what we really want to know is if the deviations as observed by the retrieval match CALIOP? Further their cases are all pretty close to the surface. Perhaps add a Siberian smoke plume case?

Anyways, while I think this is a fine effort, the paper lacks details that are required and thus I suggest major revisions. I would encourage the authors add a few more pages too zooming in further on the

case studies so we can see what the retrieval is looking at. Maybe a figure that pulls the string through that includes a higher dynamic range of features? Best wishes with the endeavor.

[General response]

Thanks for the thorough review comments. We added discussion about how the products work in different situations (dense aerosol plume, thinner aerosol layer, multiple layers of aerosol).; Line 165-180. For the most favorable condition, the algorithm is likely to give the height near the top of the aerosol layer, we define what the algorithm gives as aerosol top height.

About the embedded clouds, we changed the algorithm to be less affected by the embedded (or nearby) clouds by removing pixels with no AHI AOD values. So, the discussion about the embedded clouds seems to be treated as an error source when AHI AOD fails to screen out cloud pixels. Therefore, we mentioned the effect of embedded clouds in Section 3.3 with an additional cloud screening process in the current revision.; Line 202-205.

To give insights into the retrieval quality from our algorithm, we conducted error analyses of AHI-AGRI ATH. Please note that the retrieval algorithm is changed. We generated two heights from the CALIOP profile. One is called "90 % extinction height", which was used in our manuscript. The other is "extinction weighted mean height" which was used over other studies using spectroscopic methods such as Nanda et al. and Chen et al (2021).

$$\text{ext. weighted mean height} = \frac{\sum_{i=1}^{n} \beta_{ext,i} Z_i}{\sum_{i=1}^{n} \beta_{ext,i}}$$

where $\beta_{ext,i}$ is extinction coefficient at 532 nm at height index i and Z_i is the altitude at i.

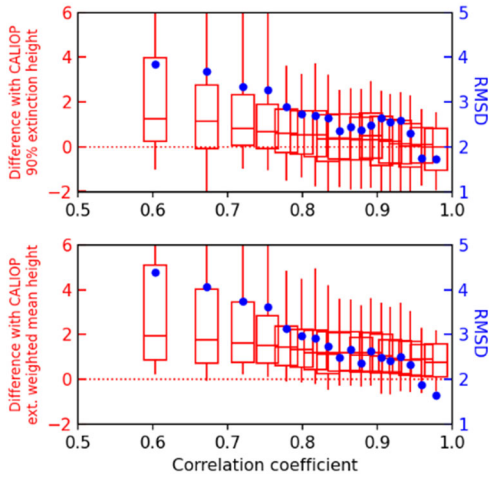

Figure AR1 Comparison with CALIOP 90 % extinction height (upper) and CALIOP extinction weighted mean height (lower) according to correlation coefficient of best correlated moving window during image-matching process. Red boxplots show 5th, 25th, 50th, 75th, 95th percentiles of (retrieved ATH – CALIOP height). Blue circles show RMSD of retrieved height and CALIOP height.

Here, the "correlation coefficient" means the value of the best correlated moving window (from the matching image) for a fixed window (from the reference image). As shown in figure AR1, it can be seen that as the correlation coefficient becomes higher (which means that the algorithm successfully found the same aerosol layer on the image), the retrieval bias gets close to 0, and RMSD decreases. We then compared error analysis from all correlation coefficient data and that from quality-controlled

(correlation coefficient > 0.95) data.

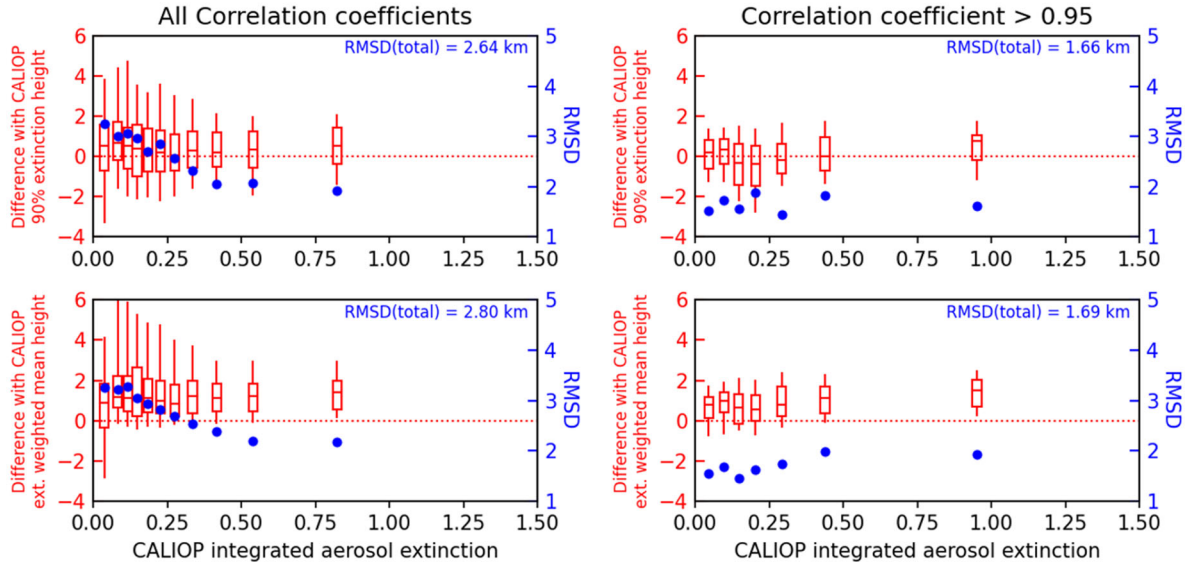

Figure AR2 Same as Fig. AR1. But according to CALIOP integrated aerosol extinction. Left panels are for all correlation coefficient values while right panels are only for correlation coefficient > 0.95.

Error analyses according to aerosol loading (column integrated CALIOP L2 aerosol extinction coefficient). Using all data regardless of the correlation coefficient, retrieval quality increases as aerosol loading increases. In this case, RMSD with CALIOP 90% extinction height (extinction weighted mean height) decreased from 3.21 (3.08) km to 2.07 (2.35) km. Meanwhile, using quality-controlled (correlation coefficient > 0.95) data, the total RMSD was 1.66 km. Therefore, we could say that our results are compatible with other studies.

Additionally, comparing both 90 % extinction height and extinction weighted mean height to the stereoscopic ATH. We could also inductively say that the stereoscopic algorithm gives an altitude that is near the top of the aerosol layer.

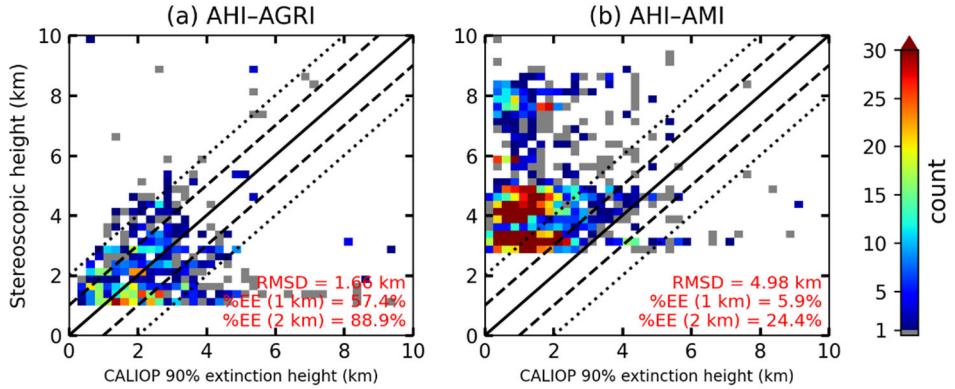

Figure AR3 2-dimensional histogram of CALIOP 90% extinction height and stereoscopic ATH of AHI-AGRI (a) and AHI-AMI (b).

The scatter plots in Fig. 8 are "scene-averaged" data. We chose this because it was hard to read the plot when we draw all collocated pixels. However, averaging all the collocated values of ATH and CALIOP height can be affected by outliers. Therefore, we changed Figure 8 to 2-dimensional histograms using quality-controlled retrieval. % within 1 km from CALIOP 90% extinction height is 57.4% and % within 2 km from CALIOP 90% extinction height is 88.9% for AHI-AGRI. The same for AHI-AMI is 5.9% and 24.4%.

Line 49: "Studies have shown that the use of geometrical features of elevated atmospheric structures apparent to multiple sensor imagery is effective, rather than using computationally expensive radiative transfer calculations." Well it is more than that. Spectroscopic techniques give a different product altogether-the centroid of a plume- and that is compounded when one has multiple aerosol layers. Stereography gives a plume top for those cases when one can see a feature. This is a very different thing. In practice, I would say plume height from say MISR is more tractable than the spectroscopic methods.

We appreciate sharing your insights about the retrieved height from different approaches. We added what information spectrographic algorithms get to retrieve from observation data as "Using stereography, unlike spectroscopic algorithms, one gets to retrieve feature top height." in line 53-54.

Line 72: "Cloud top heights have been successfully retrieved using geometrical fusion of two geostationary satellite images (Lee at al., 2020), suggesting the applicability of such a method to any structures in the atmosphere." A quick look on web of science I found several papers on the topic of stereo heights for aerosol features worth mentioning-some of which have a lot of parallels to this paper, including Lee et al (2020)-Remote Sensing; Merucci et al., (2016)-Remote Sensing.; Prata and Lynch (2019)-Atmosphere just to name a few. And for clouds there are many more. So the field is more advanced than the paper is letting on.

Thank you for your suggestions on additional references. We added other references (Hasler, 1981; Seiz et al., 2007; Zašek et al., 2013; Merucci et al., 2016) that showed LEO/GEO stereoscopic ash/metrological cloud top height retrievals.; Line 76

Line 73: "However, aerosol layers are not as optically thick as clouds and their heights are much lower than cloud tops, so the applicability and accuracy of the geometrical method for estimating ATH remain unresolved" I am not sure what you mean by using the word "unresolved" here. You can say that about anything really. You can say it is in the early stage of development. But given the complexity of the system it may never be "resolved"

What we tried to deliver with the word "unresolved" was that since the previous studies are focused on clouds or volcanic ash plumes, the application of the geometrical feature height retrieval needs to be tested for aerosol layers in East Asia, where aerosol layers are formed due to surface pollution emission thus much thinner/lower than clouds or volcanic ashes. Sorry for the confusion. We changed the sentence to "However, typical aerosol layers are formed due to surface pollution emission in East Asia thus are not as optically thick as clouds or volcanic ash plumes. Also, aerosol layers tend to be at a much lower height than cloud or volcanic ash plumes. So, the applicability and accuracy of the geometrical method for estimating aerosol feature height needs to be investigated".; Line77-80

Line 117: "Their ability of lidar observations to produce aerosol profile data with high vertical resolution enables them to be a validation standard for spaceborne aerosol height retrieval algorithms." I think you mean the? Keep in mind, it is best not to use pronouns in the first sentence of a paragraph. It is often unclear what "they, them, it" refers to.

Thank you for pointing out the ambiguity. We rephrased it as "Through intercomparison with aerosol profile data from lidars, spaceborne aerosol height retrieval algorithms with passive sensors can be evaluated.".; Lines 123-124

Line 153-Here you reference Lee et al., 2020, but I don't think it is in the references.

Sorry for the confusing references. Since the fact that the stereoscopic ATH retrieval is based on other LEO/GEO cloud/volcanic ash top height retrieval algorithms is shown in Section 1., we deleted the sentence.; Line 157

Line 225: "Although highly reflective clouds can interfere with correlation calculations, the stereoscopic ATH algorithm does not include a cloud masking procedure. By using the AHI AOD product, where retrievals are undertaken only for cloud-free pixels, we assume that selected pixels with high AOD are cloud free." Is that a good assumption? So also what happens when you have a thick smoke or dust plume? If the retrieval fails under these circumstances some of the strongest aerosol features may be missed. In future versions, the authors may want to think hard about the aerosol-cloud discrimination.

We are aware of the aerosol-cloud discrimination that follows when using AHI AOD data. Considering that this study aims to examine the feasibility of stereographic atmospheric feature retrieval method to aerosol layers, developing an internal could-aerosol discrimination procedure is of too much complexity. Since we got reasonable results with the pair of AHI and AGRI, we are planning to further advance our algorithm containing internal high aerosol loading detection.

Line 292: It is unclear to me how the CALIOP heights should be generated. The discussion of CALIOP in this and the data section is brief. To do a proper match up, CALIOP needs to observe a feature, which has high enough AOD and texture for the matching algorithm to identify it as a target. CALIOP may be able to give the AOD, but what about the texture feature? This is not really described in the paper, but is the lynchpin problem. For the discussion with Lee 2021, they had to do a extinction weighted mean to compare apples to apples. For this paper the CALIPSO baseline "We therefore define CALIOP height as the height where the cumulative EC532 represents 90 % of the total column integrated EC532, starting from the bottom of the profile." But this has no feature identification. If you have a plume embedded in a polluted atmosphere you could be looking at completely different things.

We agree with you. For the proper CALIOP height match-up, it would be best to find the altitude that has enough aerosol loading and shows texture for the image-matching to work. However, searching for horizontal texture in the CALIOP profile data was challenging because it gives only 1-axis for the horizontal plane (narrow footprint of ~70m; Winker et al. 2010). The reason why we set the CALIOP height as "the height where the cumulative EC532 represents 90 % of the total column integrated EC532, starting from the bottom of the profile." is because we defined the retrieved stereoscopic height as aerosol top height (please, refer to the general response). For the methodology for the definition of CALIOP profile top height, we referred to Lee et al. (2015).

To check if different definition of CALIOP height would be better for the comparison with stereoscopic ATH, we also conducted an error analysis with extinction weighted mean height (Fig.AR1, AR2). The results show that compared to the CALIOP extinction weighted mean height, stereoscopic aerosol height has a systematic positive bias. Therefore, we inductively concluded that the definition of CALIOP height as "the height where the cumulative EC532 represents 90 % of the total column integrated EC532" is reasonable.

However, we see that the discussion on the definition of CALIOP height is too brief. So, we mentioned the difficulty of getting horizontal texture of aerosol layer from CALIOP data. Also, the word "CALIOP

height" seems ambiguous. So, we added more explanation and changed the expression "CALIOP height" to "CALIOP 90% extinction height". Please find the revised paragraph on lines 310-317.

Line 306: Why were these cases picked? Perhaps you should pick some with more dynamic range, like a Siberian smoke plume

The case of Fig. 6 (23 January 2020) represents a case of an aerosol layer that is out of retrieval sensitivity for the AHI-AMI pair but is retrievable with AHI-AGRI. We tried to show a case of a higher aerosol layer with Fig.7 (8 April 2020) which had an aerosol layer reaching 6 km altitude. We picked cases where CALIOP flew over the aerosol layer. Unfortunately, we couldn't find Siberian smoke plumes having valid CALIOP profile data within the study area. For the Siberian smoke plumes out of the area of interest, they were frequently found over 65°N, where AHI AOD cannot retrieve AOD because of high solar zenith angle. Therefore, we tried to pick a scene and retrieve stereographic aerosol height regardless of AOD values. However, coarse spatial resolution near the edge of images made the resampling process AGRI (or, AMI) pixels farther than 5 km from AHI. This made a too much-smoothed image. As a result, the image-matching process couldn't work properly.

We added more discussion in Sect 4.1, where we mentioned briefly the coarser resolution making retrieval unfavorable (lines 272-274), to clarify why we set the study region as East Asia. Additionally, we added characteristics of aerosols in East Asia that the stereographic algorithm focused on during development. The updated discussions can be found on the lines 77-80.

Line 345: Looking at the scatter plots, it is not clear to me what skill this method even has for the cases they are investigating. If one assumes a simple baseline from climatology (say the mean from CALIOP or maybe 3.5 or 4 km), does this method provide any skill beyond that? Here I am more worried about the RMSD than the bias. Anything systematic you can say about what situations it works and when it doesn't overall? This really needs to be added to the paper.

As shown in the general response, we conducted an error analysis and calculated RMSD for CALIOP 90 % extinction height. The error analysis for AHI-AMI is also done and we want to provide the results as supplement figures (Fig. AR4). Also, the scatter plots that show "scene-averaged" height are replaced with a 2-dimensional histogram of all collocated points. Unfortunately, a few points show ATH over 5 km. However, studies about CALIOP aerosol height climatology in East Asia (Liu et al. 2019; Gui et al. 2022) show that aerosol layers in East Asia are usually under 5 km. We are planning to broaden the study area towards South Asia, where elevated biomass burning smoke is observed.

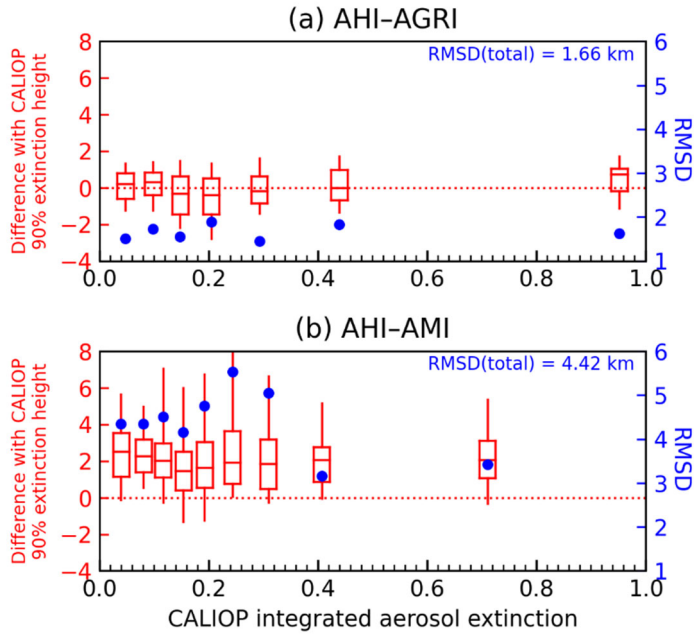

Figure AR4 Same as right panels of Fig. AR2. But showing error analysis of AHI-AGRI ATH (a) and AHI-AMI (b).

Line 370: I think an error distribution like was done with CALIOP would help synthesize your findings.

We agree that long-term validation with ground-based lidar data would help demonstrate the feasibility of the stereographic aerosol height retrieval algorithm. Unfortunately, for the period from 1 January 2020 to 30 April 2020, only 49 days are collocated within 5 km from the lidar site. According to a conversation with Dr. Yeo, who provided us with the lidar data of SNU and GSN sites, the lidar signal would be totally dissipated when a thick aerosol layer is present. This indicates that a favorable condition for stereoscopic aerosol height retrieval algorithm is not the case for ground-based lidars. Also, the ground-based observation system needs manual maintenance, which leads to fewer data availability of ground-based lidar.

The objective of the comparison with ground-based lidar data is to show the possibility to monitor diurnal variation of aerosol height using geostationary passive sensors. Since many studies that used LEO satellites cannot monitor the hourly variation of aerosol vertical features, it is one of the strengths of the stereoscopic aerosol height retrieval algorithm using GEO satellites. We notice the need to clarify the purpose of comparison with ground-based lidar. Therefore, we put additional discussion as follows in lines 381-383.

<References>

Chen, X., Wang, J., Xu, X. G., Zhou, M., Zhang, H. X., Garcia, L. C., Colarco, P. R., Janz, S. J., Yorks, J., McGill, M., Reid, J. S., de Graaf, M., and Kondragunta, S.: First retrieval of absorbing aerosol height over dark target using TROPOMI oxygen B band: Algorithm development and application for surface particulate matter estimates, Rem. Sens. Environ., 265, ARTN 112674, doi:10.1016/j.rse.2021.112674, 2021.

Gui, L., Tao, M., Wang, Y., Wang, L., Chen, L., Lin, C., Tao, J., Wang, J., and Yu, C.: Climatology of

aerosol types and their vertical distribution over East Asia based on CALIPSO lidar measurements., Int. J. Climatol., 1-13, doi:10.1002/joc.7599, 2022.

Hasler, A. F.: Stereographic observations from geosynchronous satellites: An important new tool for the atmospheric sciences., Bull. Am. Meteorol. Soc., 62, 194–212, 1981.

Lee, J., Hsu, N. C., Bettenhausen, C., Sayer, A. M., Seftor, C. J., and Jeong, M. J.: Retrieving the height of smoke and dust aerosols by synergistic use of VIIRS, OMPS, and CALIOP observations, J. Geophys. Res. Atmos., 120, 8372–8388, doi:10.1002/2015jd023567, 2015.

Liu, D., Zhao, T., Boiyo, R., Chen, S., Lu, Z., Wu, Y., and Zhao, Y.: Vertical Structures of Dust Aerosols over East Asia Based on CALIPSO Retrievals., Rem. Sens., 11, 701, doi:10.3390/rs11060701, 2019.

Merucci, L., Zakšek, K., Carboni, E., and Corradini, S.: Stereoscopic estimation of volcanic ash cloud-top height from two geostationary satellites. Remote Sens., 8, 206, 2016.

Nanda, S., de Graaf, M., Veefkind, J. P., Sneep, M., ter Linden, M., Sun, J. Y. T., and Levelt, P. F.: A first comparison of TROPOMI aerosol layer height (ALH) to CALIOP data, Atmos. Meas. Tech., 13, 3043–3059, doi:10.5194/amt-13-3043-2020, 2020.

Seiz, G., Tjemkes, S., and Watts, P.: Multiview cloud-top height and wind retrieval with photogrammetric methods:Application to Meteosat-8 HRV observations., J. Appl. Meteorol. Clim., 46, 1182–1195, 2007.

Winker, D. M., Pelon, J., Coakley, Jr. J. A., Ackerman, S. A., Charlson, R. J., Colarco, P. R., Flamant, P., Fu, Q., Hoff, R. M., Kittaka, C., Kubar, T. K., le Treut, H., McCormick, M. P., Mégie, G., Poole, L., Powell, K., Trepte, C., Vaughan, M. A. and Wielicki B. A.: The CALIPSO Mission: A Global 3D View of Aerosols and Clouds, Bull. Ameri. Meterol. Soc., 1211-1229, 2010.

Zakšek, K., Hort, M., Zaletelj, J., and Langmann, B.: Monitoring volcanic ash cloud top height through simultaneous retrieval of optical data from polar orbiting and geostationary satellites. Atmos. Chem. Phys., 13, 2589–2606, 2013.