<u>General comments</u>:

The reviewed paper entitled by "Retrieval Algorithm for Aerosol Effective Height from the Geostationary Environment Monitoring Spectrometer (GEMS) (Park et al., 2023)" introduces the newly developed GEMS aerosol effective height product and shows the initial results of aerosol vertical structure information. This is an interesting new product with a little heritage. Introduces and adds an important value in the community regarding the aerosol height retrieval from passive satellite sensors. This type of products are scarce and satellite instruments that monitor aerosol height are needed to constrain models. I suggest that the paper deserves to be published, but there are many unclear descriptions in the manuscript and the presentation quality, especially the English grammar and writing style needs to be improved. I leave this task to the co-authors and to the copy-editing service of AMT. I would appreciate the authors to address the comments below, before the final publication, as I believe they will help the readers.

Abstract section. The bias value for CALIOP and GEMS comparison is not provided in the abstract, only the STD. Please add the statistic metric.

Introduction section. A general message is missing in the introduction part to highlight the importance of having a product for the height of the aerosol layer. (e.g. "Height information for aerosols in the free troposphere is particularly important for aviation safety. Scientific applications include radiative forcing studies, long-range transport modelling and studies of cloud formation processes. Etc etc")

Comments/ suggestions for TROPOMI/S5P section. Although the aerosol layer information by the environment satellite missions is limited, several previous studies were investigated including sensitivity results and methodologies. Provide findings of these works adding the relevant references.

Some specifics comments:

- What height does the TROPOMI ALH algorithm refer to? above ground (a.g.l) or above sea level (a.s.l)? Please clarify.

- Another point that has to be mentioned is the challenge of S5P to detect ALH over land due to surface albedo issues. I suggest providing a relevant reference about that.

- Is there any limitation regarding the upper and lower limit (for pressure or height) of TROPOMI algorithm to retrieve the ALH product?

The reader should have some knowledge about the product limitations, used in the study. The S5P AER_LH product limitations is not clear. I suggest adding some details and relevant references highlighting that. In the description of the ALH product, it should be stated that ALH retrievals have been validated using the multi-year EARLINET aerosol record (Michailidis et al., 2023), and, similarly, the ALH parameter have been evaluated with CALIOP retrievals onboard CALIPSO (Nanda et al., 2020). More specifically, the paper of Michailidis et al. 2023 provides several sensitivity

analyses that detail the importance of the aerosol height under different conditions (multilayered structure, surface type, aerosol type).

Conclusions section. A final message is missing. Please if is feasible, provide a concluded comment on the future satellite missions that will be use Aerosol Height products. What is missing from the presented comparison results which would be beneficial in the satellite community? I also suggest adding some comments highlighting important areas of potential improvement in the current GEMS AEH product.

A section for **"Data availability"** at the end of the paper is missing. Please provide the satellite dataset sources for CALIPSO, TROPOMI and GEMS satellite platforms used in the study following the appropriate DOIs for each satellite product.

Specific comments & Technical corrections

-In several places within the text, the authors use the word "significant" without providing any statistical information. (e.g. significant dependence, significant uncertainty, significant discrepancies, etc.). Please check this, must be clear for the reader.

Line 60: "scattering material amounts". Please rephrase.

Line 63: "…for use with satellite sensors" to "…in order to be applied in passive satellite sensors."

Line 90: change "… for passive sensors …" to "… hosting passive sensors…"

Line 90: Reference "Omar et al., 2009" is missing.

Line 91: Reference "Veihelmann et al. (2007)" is missing.

Line 156: Rephrase "aerosol amounts" to "aerosol load".

Lines 192: "…absorption materials…" .Is not sounds good. Please rephrase to: "..absorbing species.." or "…atmospheric components…"

Line 237: Add the relevant reference (Veefkind et al., 2012) for the TROPOMI/S5p mission.

Line 237-239. I suggest the following rephrase: "TROPOMI is a nadir-viewing spectrometer, the only payload of the Sentinel-5 Precursor (S5P), measuring radiance in the ultraviolet, visible, near-infrared, and the shortwave infrared. The Sentinel-5P crosses the equator at 13:30 local time in a polar orbit with ascending node providing near-global daily coverage."

Line 251-253: Please specify the TROPOMI AER_LH L2 dataset version used in the study. For example v.02.00 is a generic statement. Currently four versions are existed: 02.02.00 - 02.05.00. Which one is used in the study? Also provide the reference DOI for the version according to Data Citation Guidelines V2:" Copernicus Sentinel-5P (processed by ESA), 2021, TROPOMI Level 2 Aerosol Layer Height products. Version 02. European Space Agency. https://doi.org/10.5270/S5P-7g4iapn"

Line 253: Please check the spatial resolution: 3.5 x 7.0 km (across x along track), at beginning of mission and 3.5 x 5.5 km (across x along track) since 6 August 2019.

Line 260-262: Please add the info about the footprint of the CALIOP and the Repeat Cycle time of CALIPSO.

Line 263-264: "...the spatial resolution coverage is narrow". How narrow? Add the footprint of CALIOP.

Line 266-268: How the AEH from CALIPSO is estimated? Be more specific about the methodology or/and add some references from previous studies.

Line 267: Are there any specific reasons to use 532nm instead of 1064nm? Please specify the thresholds used to filter out CALIPSO aerosol height data (for clouds?). Please add some relevant references.

Line 274: "... thin AOD pixels". Rephrase. Maybe you mean "pixels with low AOD values".

Line 277: "Yellow" change to "yellow". (Also, in lines 327 and 374)

Line 283: «For both plumes, AEH shows around 1.0~2.0 km in this case» I suggest rephrasing to: «For both detected plumes, the AEH shows similar pattern ranging between 1.0 to 2.0 km"

Lines 356-357: "To ensure the accuracy of ALH from TROPOMI, only pixels with quality assurance (QA) values greater than 0.5 were used." According to the ATBD, the ALH is very sensitive to cloud contamination. However, aerosols and clouds can be difficult to distinguish. Using this criterion for QA, are cloudy pixels excluded in the selected scenes? What about the presence of cirrus clouds? Is this type of clouds are also taken into account or additional flags need to be considered? Some details about the cloud masking procedure for TROPOMI is necessary to be added somewhere in the text.

Line 387: Based on what the limit of 50km for the AEH was chosen?

Line 388: Remove the word "As".

Lines 459-460: "As TROPOMI retrieved only ALH data with high QA values over pixels containing strong aerosol plumes...". Please specify what you mean with "high QA". Also, what the "strong" is meaning? Thick plumes regarding the AOD or UVAI? Please specify.

Line 423: Change "Aerosol height information..." to "The aerosol height parameter..."

Line 426-428: "Even if the uncertainty due to aerosol properties is fixed, the variability of AEH is affected by the sensitivity of AEH error to aerosol absorptivity." Please clarify this sentence.

Line 463: "… was insufficient". How many? Add the number of pixels.

Line 463-465: Rephrase the sentence "the operational algorithm of TROPOMI is only retrieved the ALH over absorbing dominant aerosol pixels" to "the TROPOMI operational algorithm is able to provide ALH pixel retrievals only for scenes dominated by absorbing aerosol particles".

Line 465-467: "pixels with small positive UVAI (weak absorbing cases) pixels are identified with small QA values in the offline product of ALH." The message of this statement is not clear and confuse the reader. Please rephrase and clarify what small QA means (e.g. QA<0.5?).

Line 504-505: Also add the STD values (mean±std)

Line 746-749: Update the Reference. The link is not available.

Figure 1.: I suggest changing the caption to: "A schematic illustration of AEH and ALH definitions in an idealized aerosol vertical distribution." What "idealized vertical distribution" means?

Figure 4.: Add the label "[km]" in the colorbar legend (similar to Figure 3, in first column).

Figure 7.: Add a title similar as this in Figure 5. If is possible add the label "[km]" in the colorbar legend (similar to Figure 6, first column).

Cited References:

Michailidis, K., Koukouli, M.-E., Balis, D., Veefkind, J. P., de Graaf, M., Mona, L., Papagianopoulos, N., Pappalardo, G., Tsikoudi, I., Amiridis, V., Marinou, E., Gialitaki, A., Mamouri, R.-E., Nisantzi, A., Bortoli, D., João Costa, M., Salgueiro, V., Papayannis, A., Mylonaki, M., Alados-Arboledas, L., Romano, S., Perrone, M. R., and Baars, H.: Validation of the TROPOMI/S5P aerosol layer height using EARLINET lidars, Atmos. Chem. Phys., 23, 1919–1940, https://doi.org/10.5194/acp-23-1919-2023, 2023.

Veefkind, J. P., Aben, I., McMullan, K., Förster, H., de Vries, J., Otter, G., Claas, J., Eskes, H. J., de Haan, J. F., Kleipool, Q., van Weele, M., Hasekamp, O., Hoogeveen, R., Landgraf, J., Snel, R., Tol, P., Ingmann, P., Voors, R., Kruizinga, B., Vink, R., Visser, H., and Levelt, P. F.: TROPOMI on the ESASentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications, Remote Sens. Environ., 120, 70–83, https://doi.org/10.1016/j.rse.2011.09.027 , 2012.