

Review of manuscript “Retrieval Algorithm for Aerosol Effective Height from the Geostationary Environment Monitoring Spectrometer (GEMS)”, by Park et al., 2023.

The revised paper entitled introduces the GEMS aerosol effective height (AEH) product, presenting the initial results of aerosol vertical structure information. Is an interesting new product with a little heritage adding an important value in the community regarding the aerosol height retrieval from passive satellite sensors. The main object of the manuscript, is to demonstrate the performance of the GEMS operational aerosol retrieval algorithm and to evaluate the AEH product compared to reference products from satellites such as CALIPSO and TROPOMI. The objective of this paper is clear in general, which intends to show the performance of operational GEMS aerosol product under different situations. Although the authors have generally carried out a carefully validation analysis of GEMS AEH, more parts need additional explanation before the article is acceptable for publication. I suggest that the paper deserves to be published, but first the presentation quality, especially the English grammar and writing style needs to be improved significantly. I would suggest the authors to revise the English writing style throughout the text. The paper needs to be carefully proof read. There are quite a few places that I tried to guess what the authors were trying to say.

From my perspective I tried to highlight as more as possible major and technical suggestions/corrections, making the manuscript more readable and friendly. I would appreciate if the authors followed the comments below, as I believe they will help to the manuscript improvement:

- A careful validation of the satellite product is required in order to prevent the propagation of the resulted biases. Is there any recommended criterion flag that will allow the use of maximum data reliability by GEMS? Through the manuscript the only mentioned criterion applying on GEMS data is AOD (e.g. > 0.4). Do I understand correctly?
- What is the information about the GEMS AEH data product requirements? Are there official target uncertainty requirements?
- Please, provide some guidance about the quality flags for GEMS AEH. It is necessary for each operational satellite product used in the study analysis to be accompanied by the corresponding QA indicators. Provide relative information from the respective ATBD/PUM if available for the GEMS product.
- I don't see anywhere in the “Data selection and collocation” section a detailed discussion about the methodology used by the authors regarding satellite collocation matching. A thorough information about the GEMS and TROPOMI comparison process is missing. It's important to explain and include the process.
- The reader should have some knowledge about the CALIOP product limitations, used in the study. What quality flags have been applied on CALIOP extinction profiles regarding several aspects? (such as e.g. the presence of clouds, unreliable values etc). Explain and provide necessary References.
- Are you using the AOD product from CALIPSO in your comparisons against GEMS? Since it is mentioned in the text, please explain in detail.

- How many CALIPSO orbits does the long-term analysis include in total? What are the selection criteria for the selection of the orbits?
- Please clarify the study area (domain of interest) for which this analysis is being carried out.
- For statistical correctness, add STD values where mean bias values are shown through the manuscript.
- Looking at the Figures 6a & 9a, GEMS vs. CALIOP AEH differences are quite remarkable. Obviously, the mean bias is small/within a kilometer, but the scatterplots indicate no correlation. I suggest using RMSE statistical metric throughout the analysis part, to assess the performance of the algorithm.
- The authors also leave out what they plan to do to improve the product's performance in the future. It would be useful for the reader to have a final message/discussion about the future development plans. A few sentences may be added in the conclusions.

I encourage authors to spend time studying in detail relevant articles where CALIPSO data are used for validation procedures. I give some examples:

- **Xu, X.**, Wang, J., Wang, Y., Zeng, J., Torres, O., Reid, J. S., Miller, S. D., Martins, J. V., and Remer, L. A.: Detecting layer height of smoke aerosols over vegetated land and water surfaces via oxygen absorption bands: hourly results from EPIC/DSCOVER in deep space, *Atmos. Meas. Tech.*, 12, 3269–3288, <https://doi.org/10.5194/amt-12-3269-2019>, 2019.
- **Xu, X.**, J. Wang, Y. Wang, J. Zeng, O. Torres, Y. Yang, A. Marshak, J. Reid, and S. Miller (2017), Passive remote sensing of altitude and optical depth of dust plumes using the oxygen A and B bands: First results from EPIC/DSCOVER at Lagrange-1 point, *Geophys. Res. Lett.*, 44, 7544–7554, doi:10.1002/2017GL073939
- **Chen, X.**, Wang, J., Xu, X., Zhou, M., Zhang, H., 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, *Remote Sens. Env.*, 265, 112674, 2021
- **Nanda, S.**, de Graaf, M., Veefkind, J. P., Sneep, M., ter Linden, M., Sun, J., and Levelt, P. F.: A first comparison of TROPOMI aerosol layer height (ALH) to CALIOP data, *Atmos. Meas. Tech.*, 13, 3043–3059, <https://doi.org/10.5194/amt-13-3043-2020>, 2020.

Technical/minor suggestions:

L. 53-54: “In addition, aerosol vertical information is also important information for the application.” What application do you mean? Please rephrase.

L. 59: Please Correct: “... that measure in UV-visible..”

L.128-129: Keep only the CALIOP acronym. It has been introduced previously in the text.

L. 129-130: Suggest rephrasing to: “Finally, in section 6, the summary and main conclusions are presented.”

L. 163-165: Can you elaborate further this statement?

L. 195-199: This paragraph is not so clear to me, and it is needed a rephrasing and a better explanation.

L. 224-225: Suggest rephrasing to: "To ensure that the number of retrieved observation pixels is remain statistically significant, we relax the spatial limits for collocation matching."

L. 238-241: "To consider the cloud contamination..." In addition to using QA=1 on the TROPOMI data, do you also apply additional flags as you mention for the cloud screening?

L. 316: "Although the fitting quality was good overall..." What do you mean good? Please, quantify.

L.372: Please explain what "yellow" dust means. Clarify within the text.

L.467-470: Sentence repetition (see L.437-441). Rephrase.

L.480: "the AI value for UV" to "UVAI".

Line 556. "Comparing these results to Figure 8..." There is no Figure 8b. Maybe you mean Figure 10b.

L. 556-557: "However, the standard deviation of the two surface types indicated a significant difference. Over the ocean surface, the histogram is very narrow." Provide quantitative information.

L. 562: Rephrase to: "... with low positive UVAI values..."

L. 564-567: I cannot fully understand these sentences. Please rephrase in as simple terms as possible.

L. 568: "...as shown in Figure 10b." Maybe you mean Figure 12b.

L. 570-571: "Similar to Figure 8c..." Figure 8c does not exist. Please correct.

L. 572-573: "In addition, the difference in the definition of ALH from TROPOMI and AEH from GEMS impacted the comparison." Generic statement. I'm not sure if can be used here.

L. 573-574: "Dust" types of aerosols are mainly transported in the free troposphere with gaussian-like shapes...". What do you mean? Rephrase.

L. 578-579: Rephrase to: "Transport patterns and vertical distribution shape depending on aerosol types, can affect the accuracy of aerosol height retrievals."

L. 595: "...very narrow." Add statistical details and rephrase the sentence accordingly.

L. 596-597: "Although ... distribution" Rephrase to: "Even though there are 6.5 times more data for land compared to the ocean surface, the land surface still demonstrates a relatively broad histogram distribution".

L. 598-600: Rephrase to: "This inconsistency arises due to the non-Lambertian effect, which introduces bias in surface reflectance and also influences the variability in surface reflectance associated with observation geometry". Provide a Reference.

L. 425: Rephrase to: "Figures 6b and 6c illustrate the comparison results between GEMS AEH and TROPOMI ALH, for the period of March 28 ~ 30, 2021 over land and ocean surface, respectively."

L. 451-456: It is not clear which data are used exactly. Can you provide a ...

L. 500: "L2AERAOD include significant uncertainty". Quantify "significant".

L. 509: "Causes significant variability in AEH". Quantify "significant".

L. 514-518: I think that it is missing here a comparison with other relevant studies.

L. 533: "the smallest" to "the lowest"

L. 551: I suggest to remove the "[AEH from GEMS) – (ALH from TROPOMI)]" from the text. It's large and confuse the reader.

L. 553: "The mean value of (AEH from GEMS)..." to "The mean difference value between GEMS AEH and TROPOMI ALH...."

L. 656: Rephrase "...with..." to "...against..."

L. 650-651: "... with variation of around 1.4 km based on the standard deviation for AOD > 0.4" to "...with a standard deviation of 1.4 km under the scenario of AOD>0.4"

L. 672-674: "By changing the transport patterns, the AEH can be identified the vertical distribution of aerosols by difference of AEH and ALH". I cannot understand what the meaning is of this sentence.

L. 741-742. The document cannot be accessed. Provide an updated document.

L. 873-876: Reference link does not exist. Please update the Appropriate ATBD version.

Figure 4: I suggest adding a label for each sub-figure (e.g. (a), (b) ...). It's easier for the reader. Also, a suggestion to change the caption to: «Hourly GEMS AEH product for the dust case on March 29, 2021 over East Asia, from 00:45 to 06:45UTC»

Figure 5: Are these TROPOMI Map figures, correspond to QA=1.0 for ALH? Please add the full label in the colorbar: "Altitude [km] or Aerosol Height [km]".

Figure 6. what does the red and blue dotted line represent? Please clarify in the caption. Keep the same colors in same inclinations as the above CALIPSO scatterplot. Also add the statistical metrics presented in the plots e.g. "Annotated are number of scatter points (N), correlation coefficient (R), mean difference and the percentage of data points within the error envelop (EE). "

Figure 7: See comment on **Figure 4**.

Figure 8: See comment on **Figure 5**.

Figure 9: See comment on **Figure 5**.

Figure 11: Modify the caption “.... (Black dots and error bars denote the mean and standard deviation of AEH difference, while the grey-box indicates the number of points)”

Figure 12: Histograms of differences between ALH from TROPOMI and GEMS AEH from. The labels in incorrect, showing the GEMS-CALIPSO. Please correct. Suggest to remove the “[(AEH from GEMS) – (ALH from TROPOMI)]”

Figure 13: See comment on **Figure 12**.

Figure 14: See comment on **Figure 11**.