We appreciate the reviewer's insights and helpful comments, which improved the scientific quality of our manuscript. We carefully revised our manuscript basically reflecting reviewers' comments as much as we can. Our responses to the reviewer's comments are continued below with blue highlight. Please find our responses attached below.

Authors' response to RC2

Reviewer #2: In this paper, authors presented the first results of a suite of operational aerosol products, including AOD, SSA and ALH, from Geostationary Environment Monitoring Spectrometer (GEMS), through evaluating their performance in monitoring air pollution events over Asia, and through validation against AERONET and CALIOP data. The objective of this paper is very clear, which intends to show the performance of operational GEMS aerosol product under different scenarios. The methodology in this paper is sound, solid and moderately innovative. The presentation of this paper is relatively clear, but could be largely improved. The results are significant enough to be published after some revisions. However, the manuscript needs to be reorganized to increase the clarity, some missing/misplaced figures needs to be fixes, also contains many editorial errors. It is suggested to be accepted but after some revisions.

1. The core of this paper, in my opinion, is to demonstrate the performance of the GEMS operational aerosol retrieval algorithm, which went through some updates on the original version. The updates include new hourly surface reflectance database derived from GEMS observations by using the minimum reflectance in 30 days and the background AOD derived from AERONET measurements, new cloud screening method and postprocessing approach using machine learning technique to reduce not only biases but also time-dependency of the biases (As shown in Figure 1). Therefore, descriptions of those updates (bold box in Figure 1) and GEMS algorithm itself deserve to be in more details. The authors have described/touched all aspects of the updates, but is slightly lack of details. The questions should be answered in more details include how these updates are designed and applied, and most importantly what are the impacts on the retrievals. Some of the contents in section 5 can be moved here and show the impact/improvement after algorithm updates. For example, section 2.13, 2.14 and 3, all should add examples to show the improvement. And, It is suggested that section 4 and 5 will solely focus on the evaluations of results from the latest version of algorithm.

Thanks for your comments. Based on minor comments, we further detailed the description of the GEMS aerosol algorithm in the paper. Some of the contents in section 5 were moved. In addition, we analyze how each update factor has influenced the AOD validation results. The validation period is January, April, and July of 2022. The early version of GEMS AERAOD exhibited an R of 0.511 and a Q-value of 16.27%. When using KNMI irradiance instead of GEMS irradiance and changing to spectral binning LUTs, Set1 resulted in a closer MBE of -0.074 to zero and an increased Q-value of 50.63%, approximately 30% higher than results of the early version of GEMS AERAOD. Set2, using GEMS surface reflectance, showed a slight decrease in the R-value but an improvement in the Q-value by over 7%. Finally, introducing a new cloud removal method (Set3) increased the R and decreased the RMSE, leading to an increase in the Q-value compared to Set2.

Table S1: Statistics of comparison of GEMS and AERONET AOD at 443 nm. The validation period is January, April, and July 2022. Set1 refers to the application of Section 2.1.2 (spectral binning and KNMI irradiance) to the early version of GEMS AERAOD. Set2 means applying Section 2.1.3 (GEMS surface reflectance) to Set1. Set3 implies the application of Section 2.1.4 (new cloud masking) to Set2.

	The early version of GEMS AERAOD	Set1	Set2	Set3
N	11100	12321	10065	9874
Slope	0.462	0.735	0.656	0.664
y-intercept	0.557	0.034	0.103	0.095
R	0.511	0.754	0.740	0.768
RMSE	0466	0.274	0.262	0.249
MBE	0.369	-0.074	-0.037	-0.044
Q (%)	16.27	50.63	57.22	57.88
GCOS (%)	5.61	16.65	19.81	20.16

2. Quality of the Figures needs to be improved, especially Figure 2, Figure 5 and 6. In addition, Figure S1, S2, S3 and S4 are described in text and the actually figures are missing.

Thank you for your feedback on the figures in our paper. We acknowledge the concerns regarding the quality of Figures 2, 5, and 6 and missing figures. We enhanced the clarity and resolution of Figures 2, 4, 5, and 6 and we included the missing supplemental figures (Figure S1, S2, S3, and S4). During the revision, many supplementary materials were added. Figure 2 originally displayed AOD, SSA, ALH, UVAI, and VisAI over time, but due to issues with distinguishability in the graphic, it has been modified to only show AOD, SSA, and ALH. Figure 4 and Figure 5 are enlarged for improved image quality and visibility. Figure 6 is updated to be AERONET version 3 Level 2.0, and the site symbols are significantly enlarged.

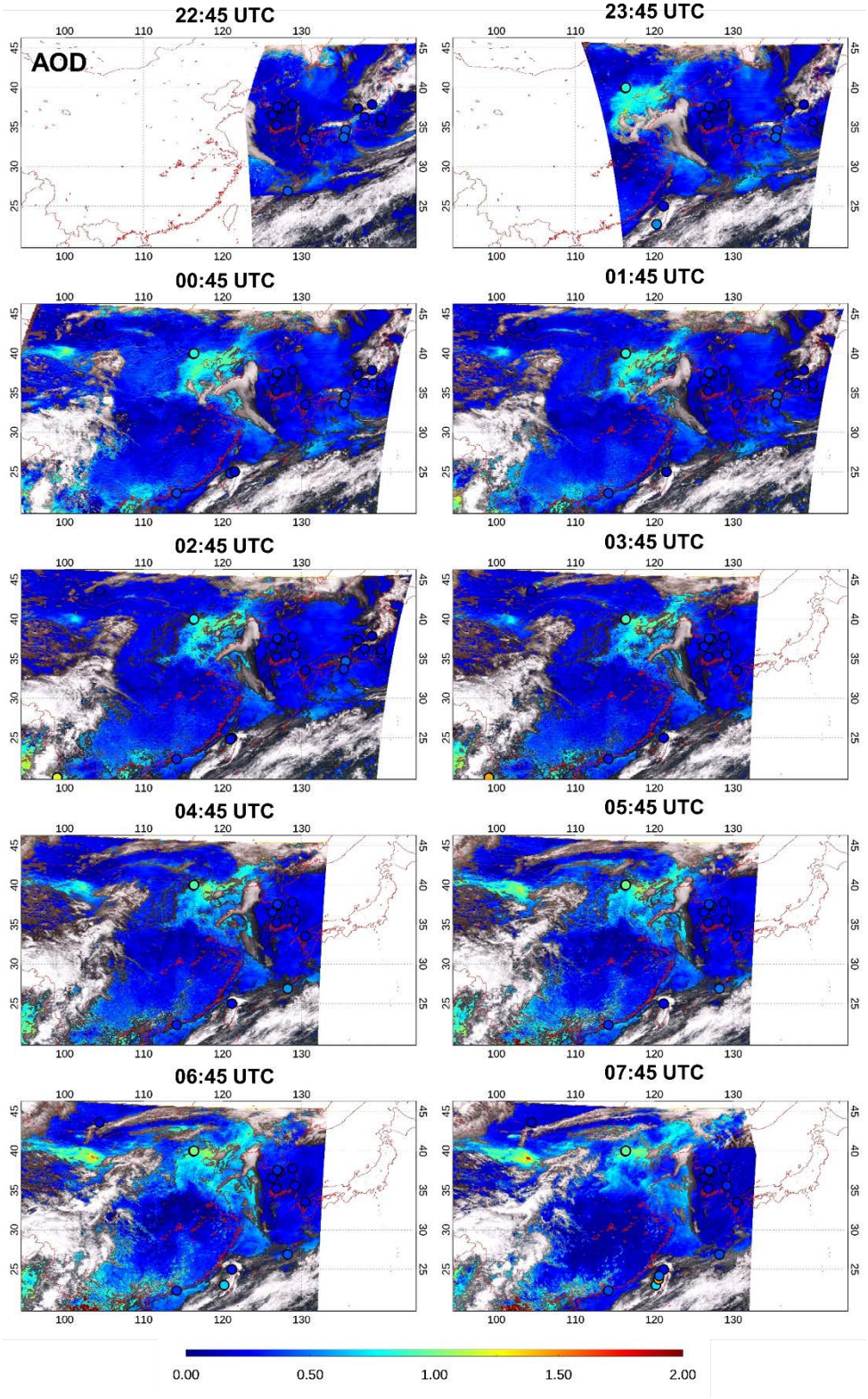

Figure 2: Hourly GEMS aerosol products for the dust case on April 8, 2022 over northwestern China. Time-series maps of AOD at 443 nm, SSA at 443 nm and ALH from 22:45 to 07:45. The circle denotes an AERONET station, and the filled color indicates the AERONET AOD and SSA at 443 nm in the AOD and SSA columns. GEMS SSA, and ALH are displayed only when GEMS AOD > 0.2.

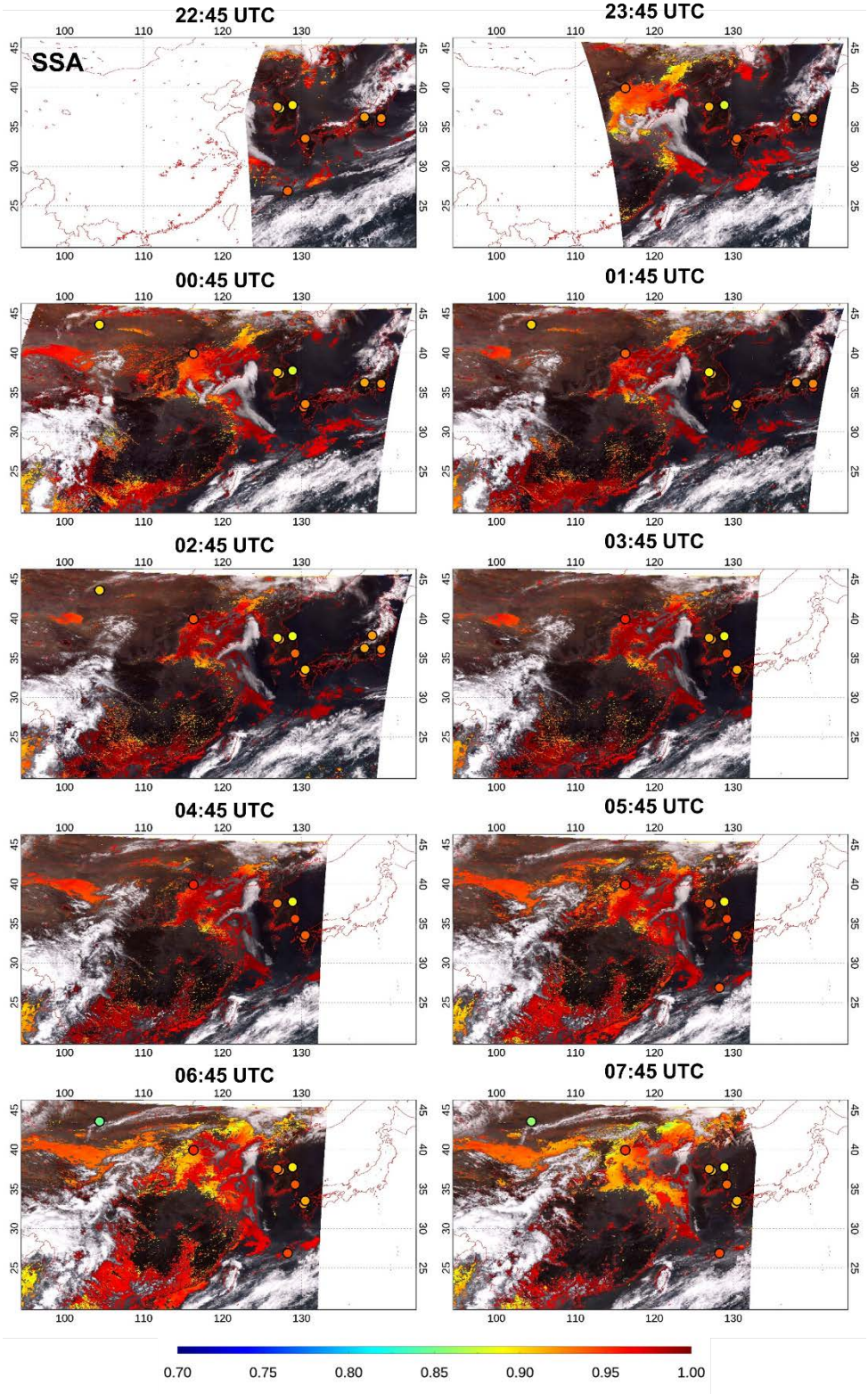

Figure 2: Continue

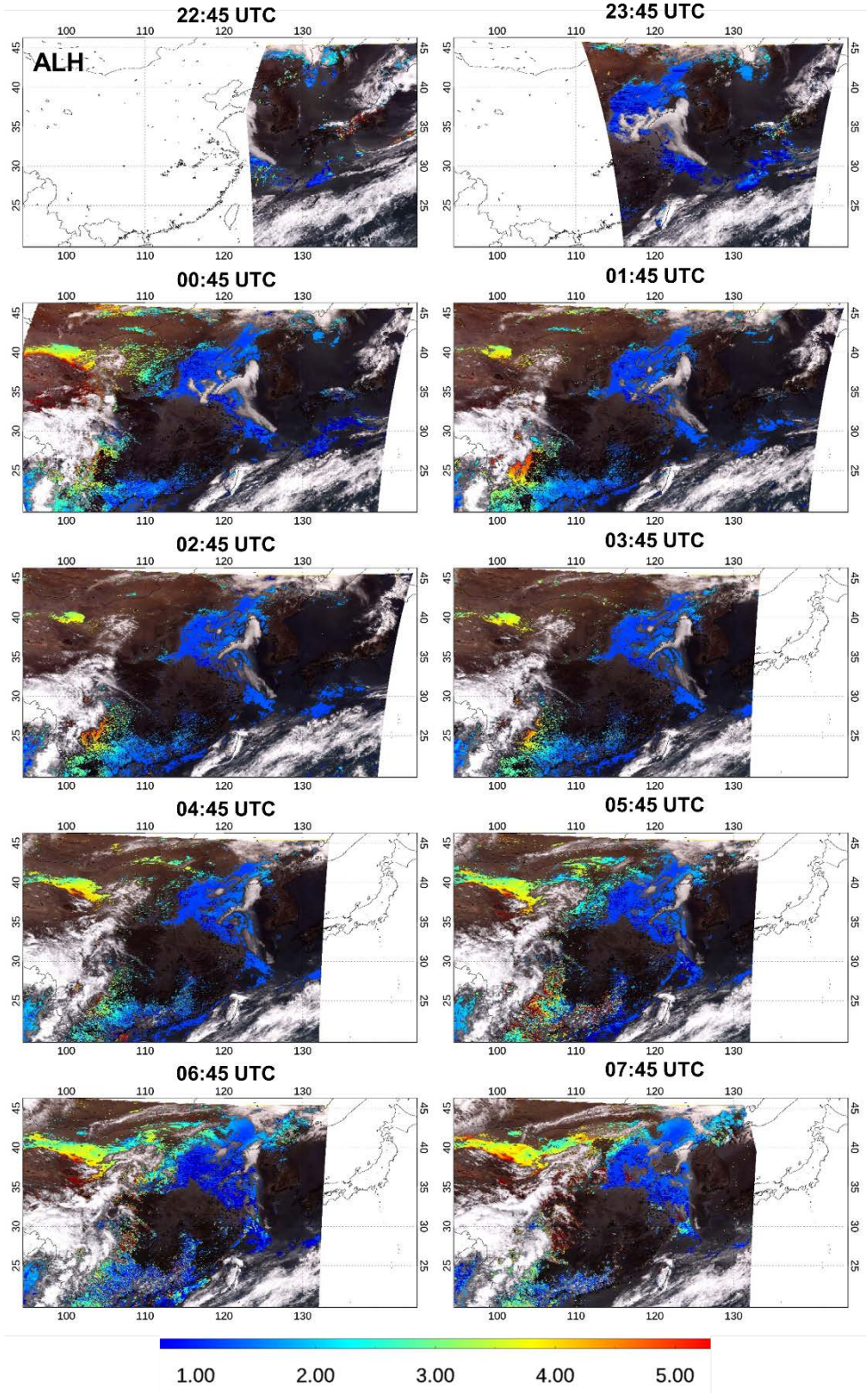

Figure 2: Continue

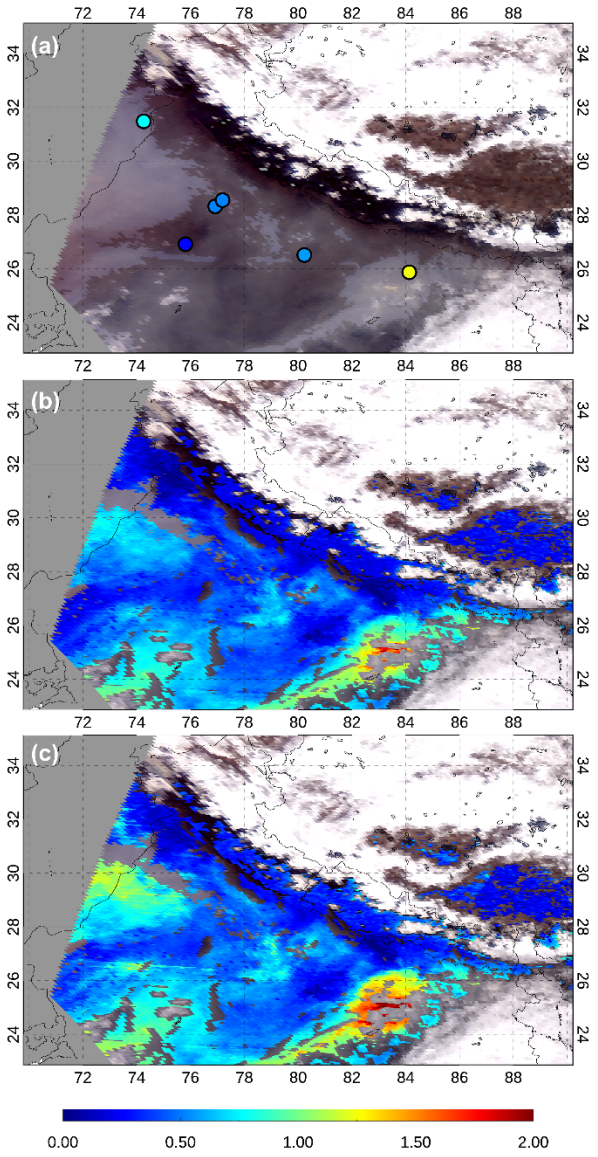

Figure 4: The example of the GEMS AOD before and after post-processing for an absorbing aerosol case over Indo-Gangetic Plane at 04:45 UTC on December 4, 2021. (a) GEMS false RGB. The circle denotes an AERONET station, and the filled color indicates the AERONET AOD at 443 nm, (b) GEMS AOD and (c) GEMS AOD after post-process correction.

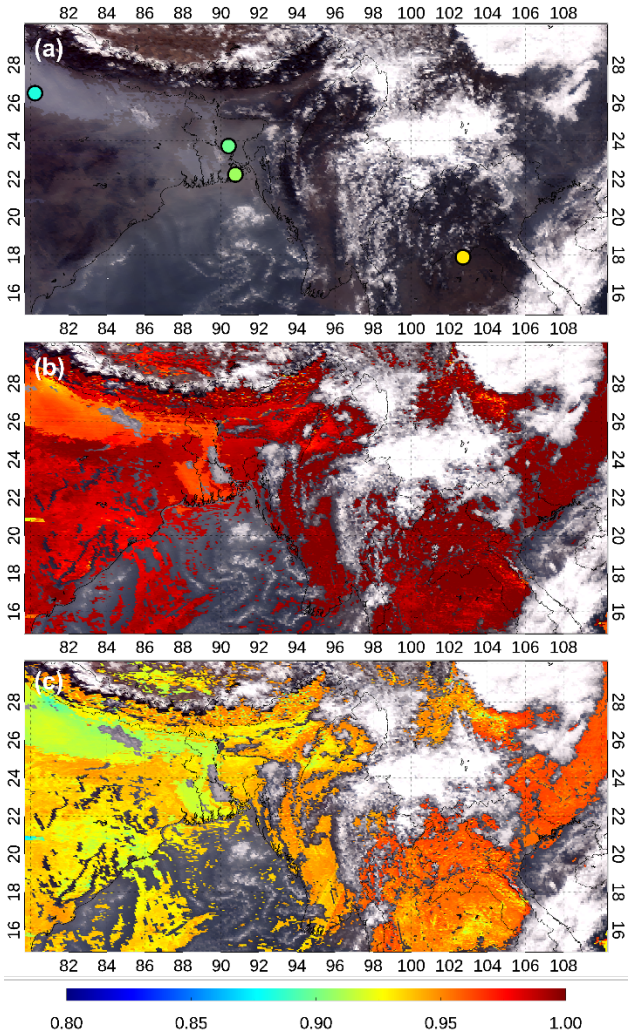

Figure 5: The example of GEMS SSA and the GEMS SSA after post-processing for an absorbing aerosol case over India, Bangladesh, and mainland Southeast Asia at 03:45 UTC on December 23, 2021. (a) GEMS false RGB. The circle denotes an AERONET station, and the filled color indicates the AERONET SSA at 440 nm, (b) GEMS SSA, and (c) GEMS SSA after post-process correction.

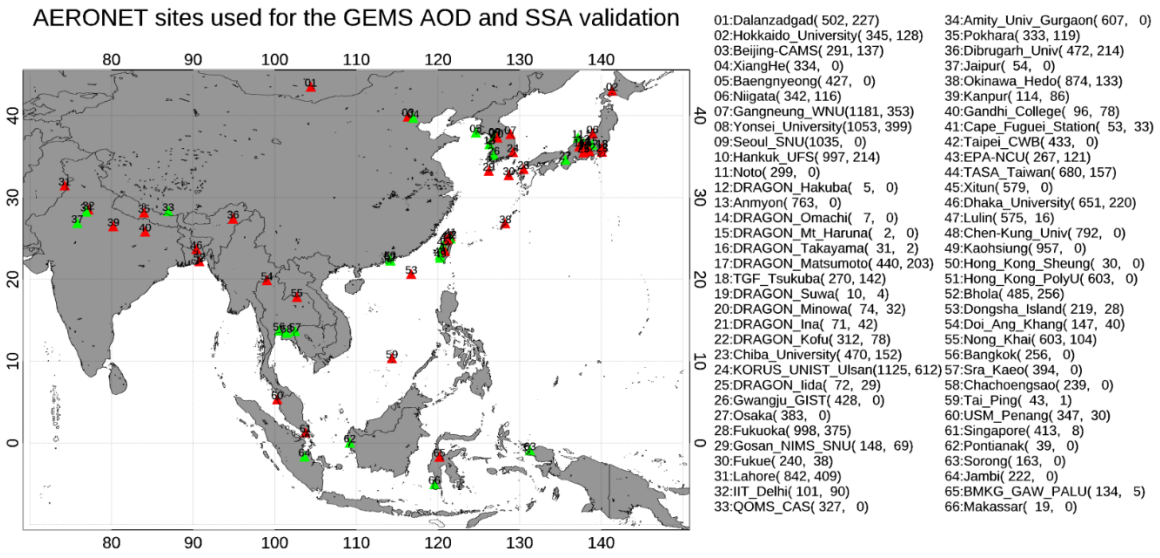

Figure 6: AERONET sites used for the GEMS AOD and SSA validation. The red color indicates the site where validation points exist for both AOD and SSA. The green color indicates the site where validation points exist only for AOD. The list of station names in conjunction with the number of AERONET AOD and SSA data points for validation at each station.

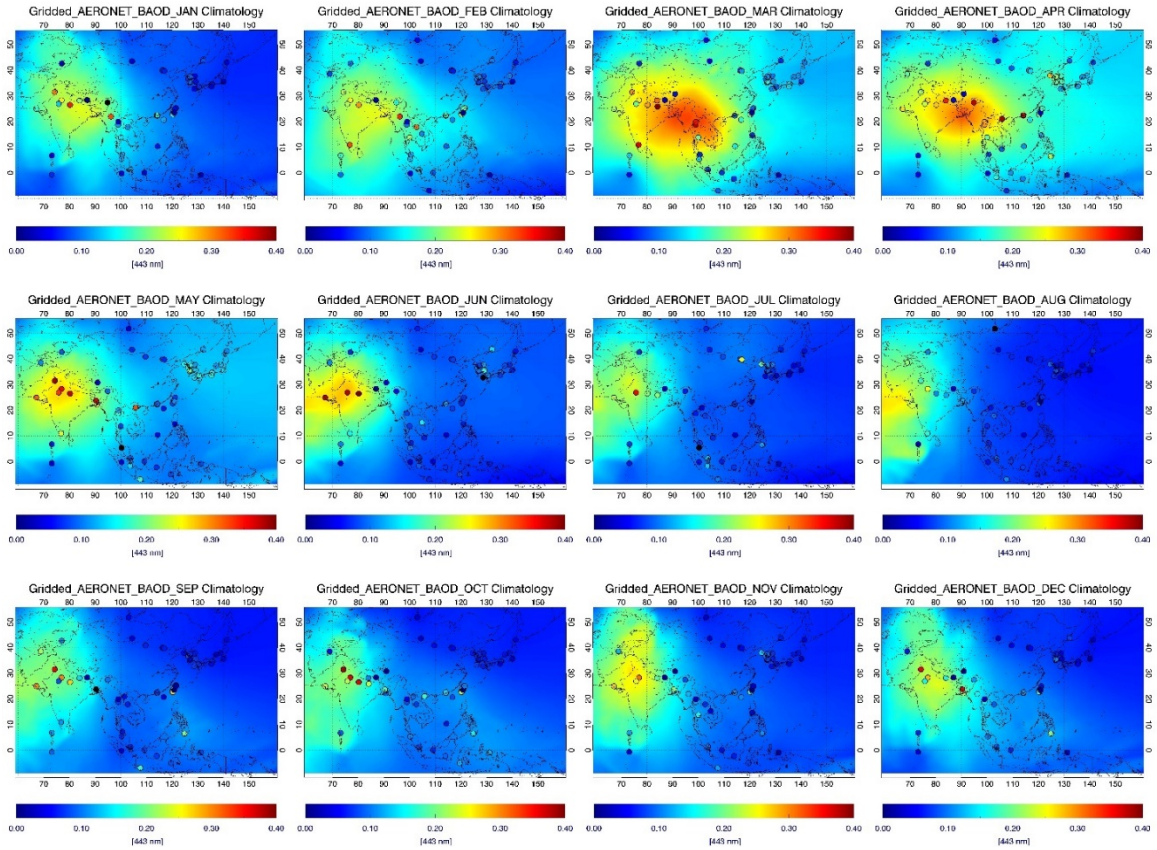

Figure S1: Monthly BAOD at 443 nm from 2-year AERONET AOD and interpolated to a 0.1 × 0.1° box. The lowest fifth percentiles of the AERONET AOD 443 nm values at each AERONET site are plotted as circles for comparison.

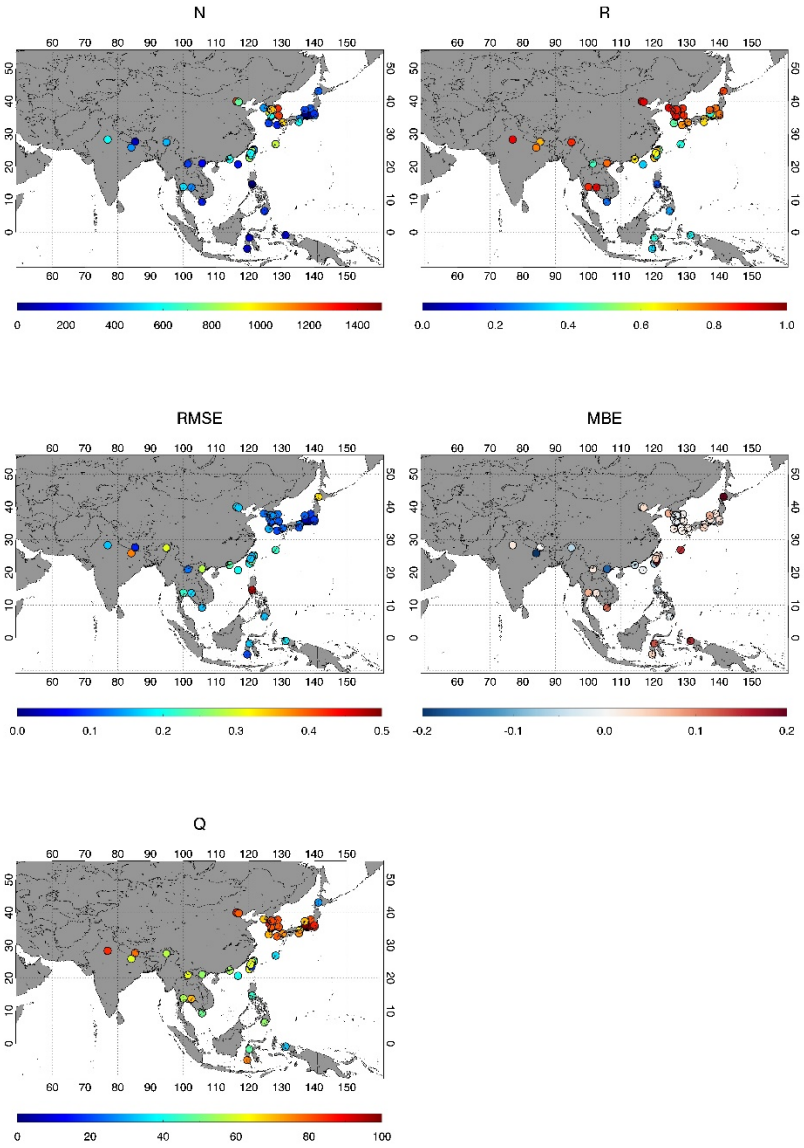

Figure S2: The statistic maps illustrating the results of site-based cross-validation for post-process corrected GEMS AOD for the 1-year period of November 1, 2021, to October 31, 2022.

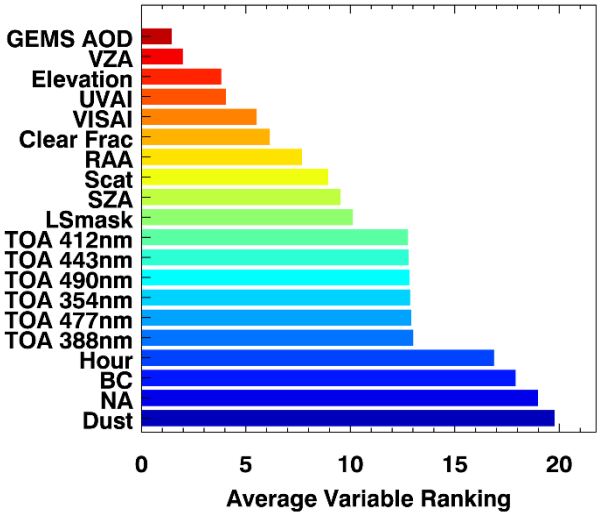

Figure S3: Average variable ranking from RF model for the post-processing correction of GEMS AOD at 443 nm for the 1-year period of November 1, 2021, to October 31, 2022.

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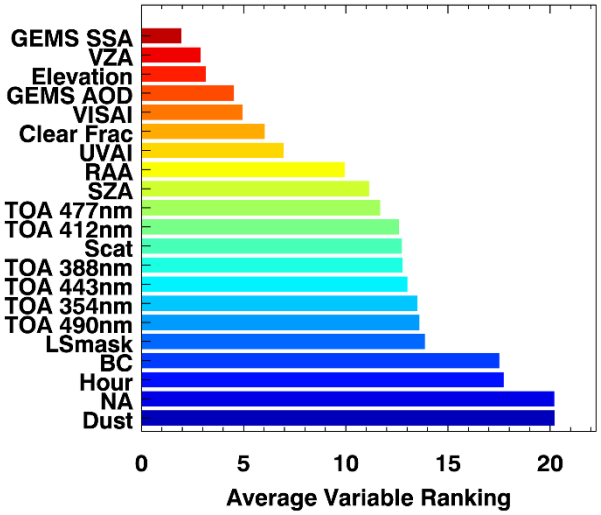

Figure S4: Average variable ranking from RF model for the post-processing correction of GEMS SSA at 443 nm for the 1-year period of November 1, 2021, to October 31, 2022.

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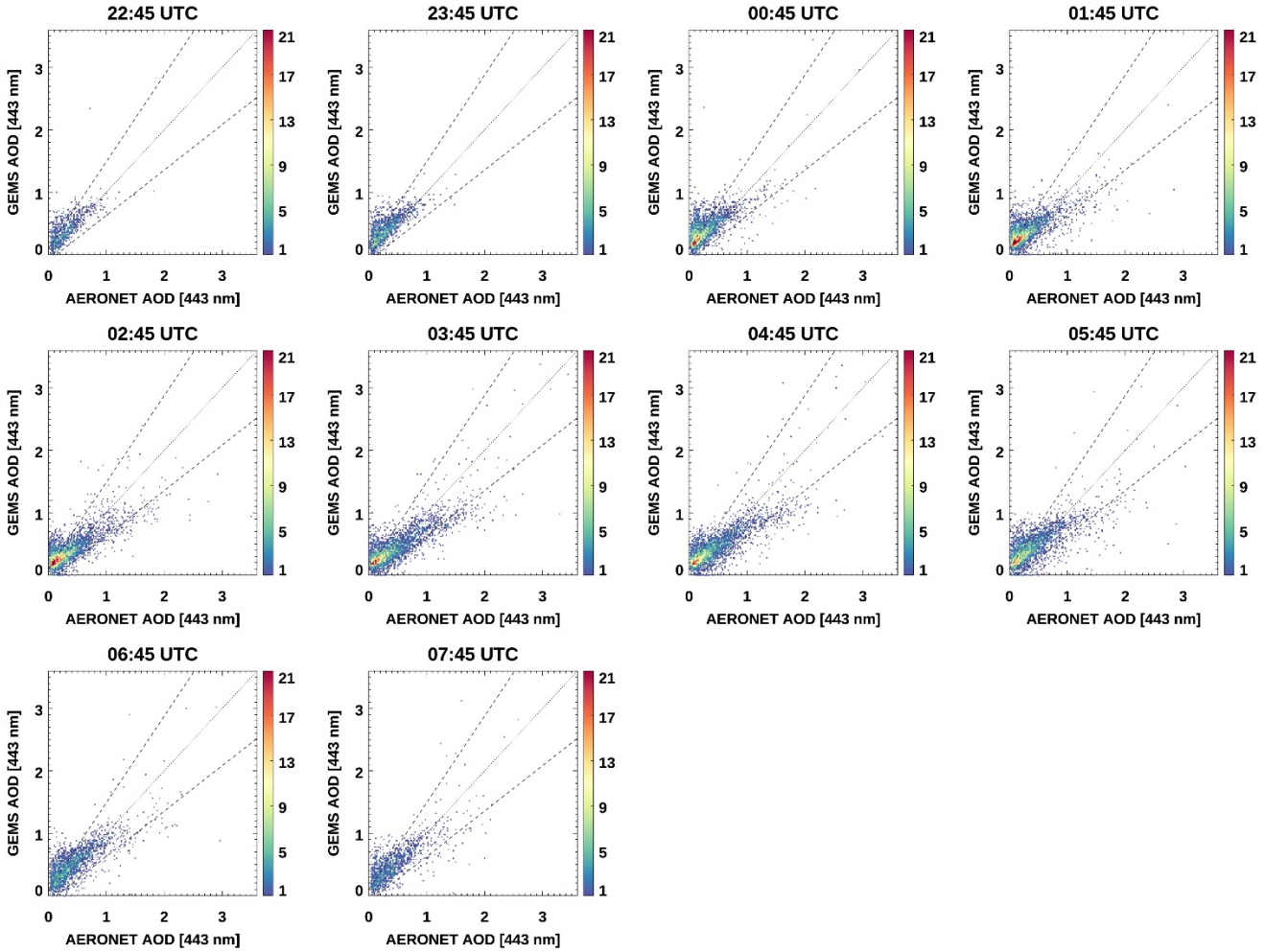

Figure S5: Hourly comparison of GEMS and AERONET AOD at 443 nm for the 1-year period of November 1, 2021, to October 31, 2022. The dashed lines indicate an uncertainty envelope of maximum (0.1 or 30%) in AOD. The dotted lines represent the 1:1 line.

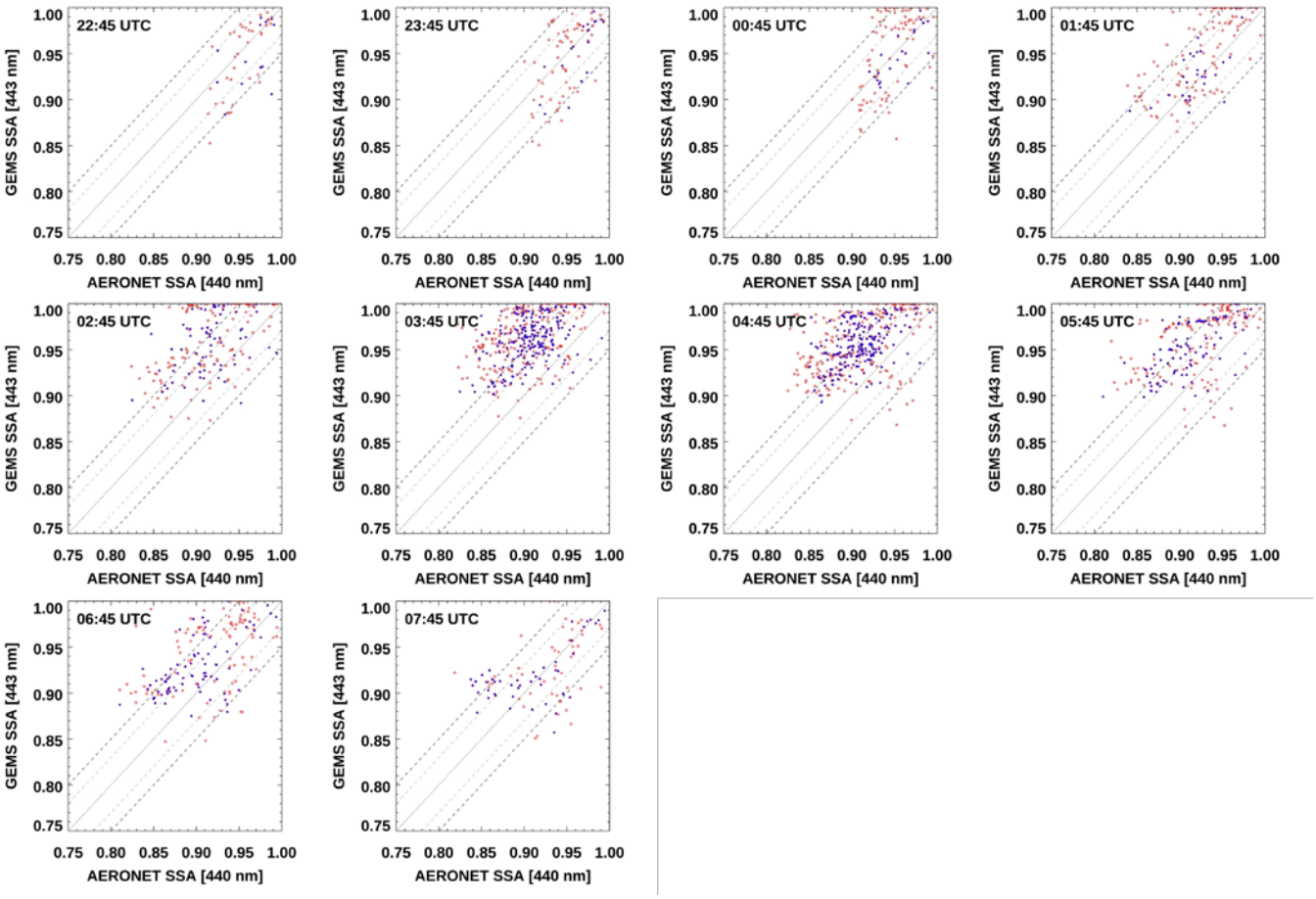

Figure S6: Hourly comparison of GEMS and AERONET SSA for the 1-year period of November 1, 2021, to October 31, 2022. The red circles represent the pixels when AOD > 0.4, and the blue circles represent the pixels when AOD > 1.0. The gray dashed lines indicate an uncertainty envelope of ±0.03 in SSA, the black dashed lines indicate an uncertainty envelope of ±0.05 in SSA, and the dotted lines represent the 1:1 line.

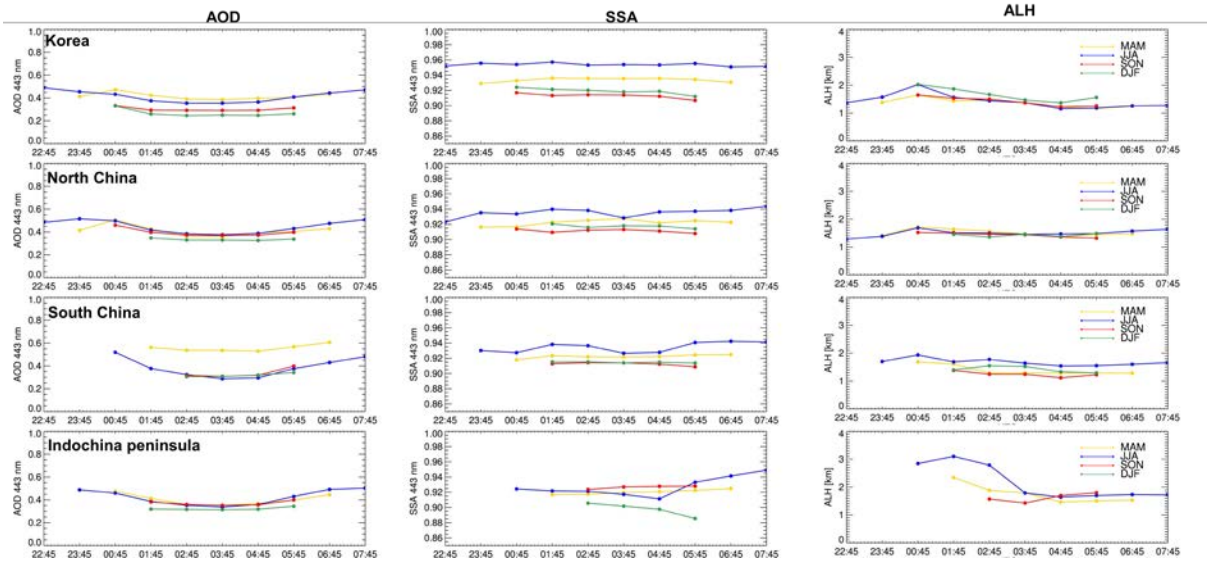

Figure S7: Seasonal and regional AOD, SSA, and ALH variation as a function of UTC for each of the following four

regions: Korea (33° N–39° N and 124° E–132° E), North China (33° N–34° N and 110° E–124° E), South China (21° N–33° N and 110° E–122° E), Indochina peninsula (8° N–22° N and 92° E–110° E) during the period of November 1, 2021, to October 31, 2022. The yellow lines represent spring MAM: March, April, and May), and the blue lines represent summer (JJA: June, July, and August), and the red lines represent autumn (SON: September, October, and November), and the green lines represent and winter (DJF: December, January, and February).

Table S1: Statistics of comparison of GEMS and AERONET AOD at 443 nm. The validation period is January, April, and July 2022. Set1 refers to the application of Section 2.1.2 to the early version of GEMS AERAOD. Set2 means applying Section 2.1.3 to Set1. Set3 implies the application of Section 2.1.4 to Set2.

	The early version of GEMS AERAOD	Set1	Set2	Set3
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R	0.511	0.754	0.740	0.768
RMSE	0466	0.274	0.262	0.249
MBE	0.369	-0.074	-0.037	-0.044
Q (%)	16.27	50.63	57.22	57.88
GCOS (%)	5.61	16.65	19.81	20.16

3. It is strongly suggested to go through editorial revision, including language, terms and sentence structures etc.

Thanks for your comments. Done. Thank you.

Minor comments are corrected.

Line 48 1 Per day or daily may be more accurate?

Done. Thank you.

line 61 This statement is a bit confusing. Rayleigh Scattering itself can not be reduced due to aerosols. It is the contribution of R1ayleigh scattering to the satellite observations.

Done. Thank you. “The contribution of Rayleigh scattering to the total Top of the Atmosphere (TOA) reflectance enhancements is reduced below the aerosol layer owing to aerosol attenuation (Kayetha et al., 2022; Torres et al., 2005).”

Line 89 "Before GEMS launches?", add "first" ?

Done. Thank you.

Line 93-96 This part needs to be rephrased to indicate that the better GEMS AOD retrieval is achieved by taking into account the spectral dependence of aerosol absorption in the UV-Vis region, which was considered as "independent" of wavelength in the previous version...

Done. Thank you. “Spectral variations of aerosol absorption in the UV-Vis region, as investigated by Go et al. (2020a), are applied to the GEMS aerosol algorithm to achieve improved AOPs retrieval. This adjustment accounts for the spectral dependence of aerosol absorption, previously treated as independent of wavelength.”

Line 96-97 please add one or two sentence to describe what the findings are ...

Done. Thank you. “To improve the accuracy of GEMS aerosol retrieval, Go et. al. (2020b) tested the use of cloud mask information from MODIS IR channels for removing cirrus and sub-pixel cloud contamination, as well as the total dust confidence index for classification of aerosol type. The limitations associated with the UV-Vis regions of GEMS were overcome by using the IR channels of other satellites, leading to the application of research on synergistic use of hyperspectral satellite instrument and broadband meteorological imager.

Line 100 "is shown as"? please rephrase tis sentence....

Done. Thank you.

Line 104-106 suggestion:

Zhang et. al. (2020) developed an empirical AOD bias-correction algorithm, which utilizes the lowest AOD.....

Done. Thank you.

Line 115 from GEMS operational observations ?

Done. Thank you.

Line 189 "with an ALH based on the climatology of CALIOP ALH" ???

Done. Thank you.

Line 198 "the same "

Done. Thank you.

Line 199 "are different from"? please rephrase this sentence.

Done. Thank you.

Line 205 owing to

Done. Thank you.

Line 213 what range?

Done. Thank you.

Line 220-223 These three sentences can be combined into one sentence and will be much easier for reader to read. Example is given as following:

"The preliminary GEMS AERAOD retrieval algorithm used the OMI surface reflectance climatology data product (OMLER v003) (Kleipool et al. 2008), with a spatial resolution of 0.5 × 0.5°, which is too coarse compared with GEMS pixel size, therefore, resulting in discontinuities in the GEMS AOPs. "

Done. Thank you.

Line 233: This section is not described clearly. How the BAOD is considered in the retrieval algorithm? is it used to derived surface reflectance dataset? if so, please described in details..

Done. Thank you.

“Rayleigh, gaseous absorption, and BAOD are corrected in the atmospheric correction process to create a surface reflectance dataset.”

Line 235: retrievals???

Done. Thank you.

Line 247: missing?

Done. Thank you.

Line 259: which band???

Done. Thank you.

Line 262: Can you explain it in more details? what the contrast mean? how?

Done. Thank you.

Line 265-267: This part is really confusing, please reorganize these sentences and give in more clear descriptions on the various steps.....

such as " (5-2) after (3-1)", what does this mean?

Done. Thank you.

Line 282: "which are calculated"

Done. Thank you.

Line 296: " limited by the fact that"

Done. Thank you.

Line 304: how about the other parameters?

Done. Thank you.

Line 307: Do you mean, "the GEMS retrieval domain coverage changes with the time due to the varying GEMS SCAN patterns with the SZA?"

Done. Thank you.

Line 310: "reaching to 2.0"?

Done. Thank you.

Line 331: higher VisAI indicated coarse particle, is it true for biomass burning event? please explain it in more details

Done. Thank you.

“GEMS VisAI didn’t clearly show signals from small particle sizes caused by biomass burning, indicating that signals from the surface were not completely removed. There may be limitations in considering aerosol size information using GEMS VisAI (Go et al., 2020b).”

Line 353: It is suggested to rephrase this sentence. "Post-processed AOD shown an elevated value, especially in the moderate original AOD range (~0.7), bring the GEMS AOD closer to AERONET AOD"

Done. Thank you.

Line 358: rephrase this sentence as " The GEMS false color RGB with AERONET stations represented by circles is given in Figure 5a"

Done. Thank you.

Line 405: Can not find Figure S2 in paper...

Done. Thank you.

Line 441: missing?

Done. Thank you.

Line 476: missing?

Done. Thank you.

Line 765: UTC or local time? please indicate them here...

Done. Thank you.