We would like to express appreciation to the reviewers for their insights and detailed review as well as for the suggested references. Our responses (in blue) for each comment (in black) are provided below.

Authors' response to RC1

The manuscript entitled by "AOD data fusion with Geostationary Korea Multi-Purpose Satellite (Geo-KOMPSAT) instruments GEMS, AMI, and GOCI-2: Statistical and deep neural network methods" are shown to the data fusion for various AOD retrieval products to enhance accuracy and stability of datasets. This manuscript showed details of statistical fusion methods and pre-processing before data fusion.

For the readability of manuscript, it needs to be checked the English correction. In addition, chapters of the manuscript must be re-constructed. In particular, some words and phrases are unclear. Although this manuscript is highly useful for the application of air quality and climate, the manuscript will be improved before publication. I summarized the details of comments.

Major comments

1) Title: This work used the AOD retrieval from GEMS, AMI, and GOCI-2, which are GK2 mission, not GK mission. I suggested that the title will change 'Geo-KOMPSAT- 2 (GK2)'. In addition, the author should check and correct this word in all manuscript.

We appreciate your suggestion; we specified the satellite mission as GK-2 on the title and also on the manuscript.

2) Introduction: This manuscript is purposed on showing the result of AOD data fusion. Although the manuscript explained several previous AOD retrieval algorithms, other product algorithms (such as aerosol index, SSA, ALH) are not essential to explain. Please simplify the introduction session more focusing on the AOD retrieval algorithm only.

Thank you for the insight. We agree that the data fusion studies outside of AOD are not essential. The introduction is simplified.

3) L92~100: For the AOD algorithms in GK-2 sensors, the manuscript will introduce details of algorithm description including advantage and disadvantage. So, please reinforcement the purpose of this research.

Thank you. Moved the corresponding paragraph in front of a paragraph regarding retrieval uncertainty due to observation wavelength.

4) Section 2: The manuscript explained the respective GK-2 sensors and applicable algorithm in the same sections. However, I suggest that the section will separate the instruments and algorithms.

We separated instrument section and algorithm description section as "2.1 GK-2 satellite instruments" and "2.2 Aerosol retrieval algorithm for GK-2 instruments". Also, details of the instrument are added.

5) L166: Please specify the uncertainty of AERONET AOD. “Uncertainty” means bias? Or precision?

Thank you. Specified as “the estimated uncertainty in precision” referring to Sinyuk et al. (2020).

6) Section 2.2: Most of AERONET sites are located on land surface. For the fusion, spatio-temporal homogeneity is important. However, the AERONET AOD, for the reference dataset of training, is not spatially homogeneous. This inhomogeneity will affect the accuracy of fusion. In addition, please list-up or make a figure for AERONET sites.

To assess whether the deep learning-based fusion accurately represents the spatial variation of AOD, we compared the fused AOD with a low Earth orbit satellite AOD product. We utilized reprocessed NOAA-20/VIIRS AOD data from the NOAA Environmental Data Record (EDR) system (Laszlo and Liu, 2022) for this comparison. VIIRS AOD data collected within 30 minutes of DNN AOD data were collocated for analysis. Figure RC1.1 illustrates that the DNN AOD aligns well with the VIIRS AOD, even for pixels that were not included in the training dataset due to sparse AERONET locations.

Also, AERONET site information is listed on Table 2.

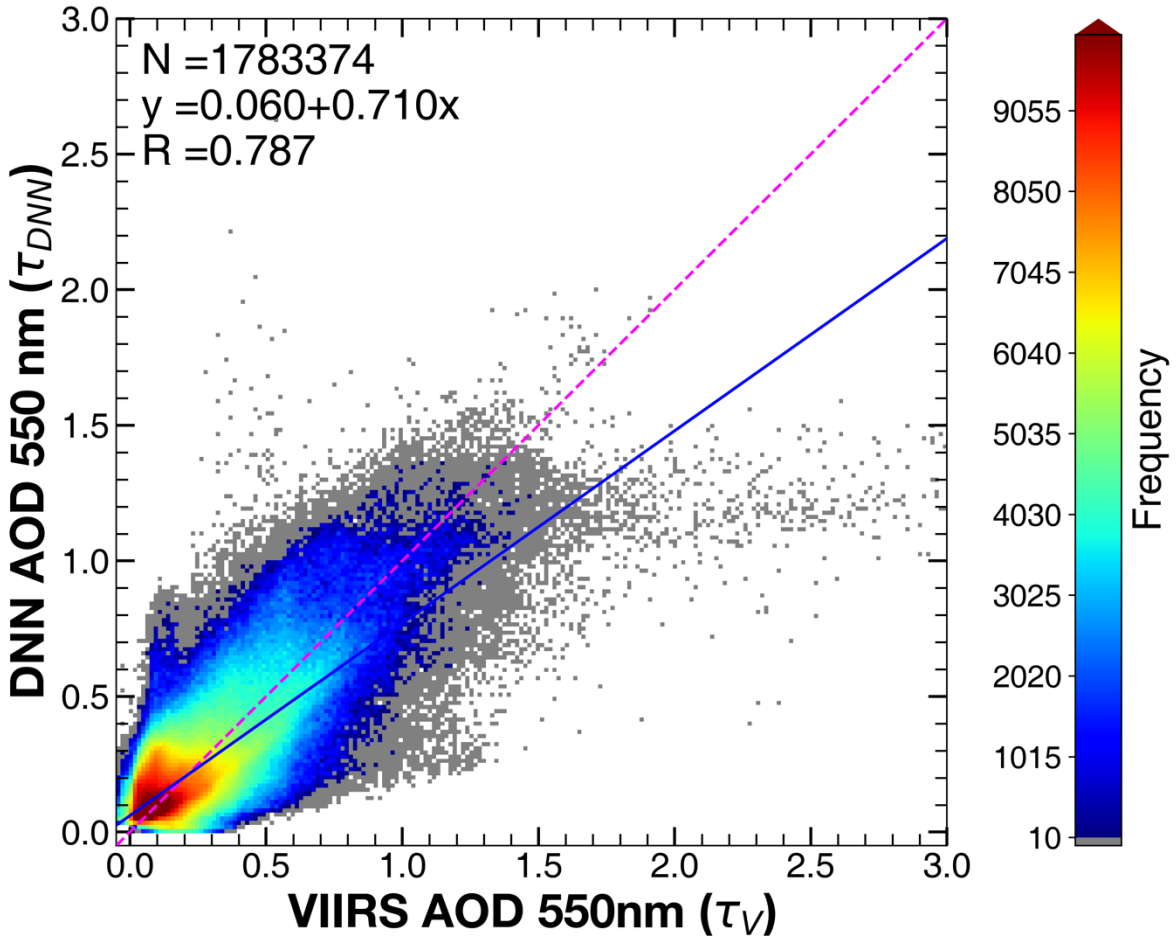

Figure RC1.1 Comparison of NOAA-20/VIIRS AOD at 550 nm and DNN AOD at 550 nm. Datasets for November 2022 are used, VIIRS AOD within 30 minutes from DNN AOD is collocated for comparison.

7) Section 3.1: Why did the dataset re-gridding? Why don’t you use the original pixel datasets for

training?

Because the geolocations of each instrument differ, re-gridding is essential to match them to a common geolocation grid. Additionally, we utilized re-gridded datasets for training to account for errors that may be induced during the re-gridding process.

We added explanations regarding the comment in Section 3.1.

8) L205: For cloud pixel identification, -28 K were used. Is that threshold also used in this study? As changing the instrument, the threshold value is also changed.

The -28 K threshold is set after testing cloud pixel identification with AMI level 1b data.

9) Section 4.1: I suggest that this section will move the method section.

Thank you for the suggestion. The section is moved to Section 3.1.

10) Section 4.3.1: Why does the author separate the regions, AOD-EA and AOD-KO?

Because of the limited field of regard of GOCI-II, the input AOD products of AOD-EA and AOD-KO are different, thus the resulting performance of fused products are different. Therefore, we conducted a separate analysis of the fused product.

11) L390~L405: To write the AERONET site name, please write the location information.

Done. Thank you.

12) Section 4.3.3: Author showed the diurnal variation of fusion AOD. However, this diurnal variation is not perfectly showed the diurnal variation. The data includes the arbitral signals during the fusion. How to be classified the real and arbitral diurnal variation from data?

The AERONET AOD on the day depicted in the manuscript reaches up to approximately 1.5, while the AOD at Yonsei_University and KORUS_UNIST_Ulsan exceeded 0.5 throughout the day. As indicated in the validation results of the fused AOD product, there is still an underestimation of high AOD values remaining after fusion. This discrepancy is attributable to the high uncertainty associated with input AOD at elevated levels. To mitigate this issue, improved input AOD data is necessary.

13) Conclusion: Please add the further study of this research to improve the fusion results.

Future study with more dataset and variables for DNN model is added as “The performance of aerosol data fusion can be improved with more dataset in the future study. For the MLE fusion, more sample leads to better representativeness of uncertainty weight for MLE. On the other hand, more dataset leads to better train performance of the DNN model. Moreover, DNN model in the future study will include more variables to predict optimal AOD.”

Minor comments

1) L15: “Geostationary Korea Multi-Purpose Satellite (GEO-KOMPSAT, GK)” à“second generation of Geostationary Korea Multi-Purpose Satellite (GEO- KOMPSAT-2, GK-2)” 2) Abstract (L22-L25): “The statistical and DNN-based ~~” is difficult to read. Please rephrase this sentence.

Done. Thank you.

3) L35: Difference of definition between ‘spectrometer’ and ‘radiometer’ is different. However, in this manuscript, the author confused to use these words.

Changed to radiometer. Thank you.

4) L134: In version 2 of the GEMS AOD at 550 nm, how to retrieve the AMS not affected by the misclassification of the type?

In version 2 of the GEMS aerosol algorithm, AOD is retrieved at 443 nm and then extrapolated to 550 nm based on the aerosol optical properties of the selected type. Consequently, errors resulting from misclassification of aerosol type can impact the 550 nm AOD. However, the AOD error stemming from aerosol type misclassification is accounted for in the uncertainty estimation. Hence, it can be inferred that the fusion algorithm incorporates errors arising from type misclassification.

5) L155: Please include the reference for GEMS algorithm.

Reference for the GEMS algorithm is in the beginning of the paragraph as “The operational GEMS aerosol algorithm, based on real observations, was subsequently established by Cho et al. (2023).”

6) L195: It is confused. Please re-describe.

Rephrased as

“For temporal matching of 04:00 UTC fusion, GEMS AOD data scanned from 03:45 UTC to 04:15 UTC were utilized as the AOD representation for 04:00. In the case of AMI AOD, data were collected for a time span of 03:30−04:30 UTC from each precise hour and a median AOD was calculated. As for GOCI-II, data scanned at 03:15 and 04:15 were simply averaged.”

7) L208: BTD10.3-13.3 is “BTD of the 10.3 and 13.3 um”. 8) L209: “atmospheric window”: 13.3 um is not an atmospheric window.

We appreciate pointing out confusing expression, thus rephrased as

“Detection of lower clouds involved the brightness-temperature difference (BTD) of the 13.3 and 10.3 μm (known as the “atmospheric window”) bands (BTD10.3–13.3).”

9) L288: “0.05+0.15AOD” 10) L303: Kim, M. et al. -> Kim et al.

Done. Thank you.

There are two “Kim et al. 2021”s in the manuscript, two of them are identified as “Kim, M. et al.” and “Kim, D. et al.”.

11) L306: Please specify the wavelength of AOD. In addition, please clarify the wavelength of AOD in all description.

Specified as “Wavelength of AOD used for error analysis and data fusion are at 550 nm.” In L XXX.

12) L349-L360: Please add the table of statistical AOD results before and after fusion.

Please refer to the Tables 5 and 6 added to the manuscript.

13) L379: What is ‘EE gradient’? Is that frequently used?

The expression is fixed to “EE slope” and the value (0.15) is also specified.