

We thank the reviewers for the helpful comments and their time for reviewing the manuscript. The detailed responses to all the referees are provided below in blue font.

Response 2

This manuscript presents a valuable decadal, hourly, high-resolution (2 km) aerosol optical properties (AOPs) dataset for East Asia, derived from GOCI satellite observations and the Yonsei Aerosol Retrieval Algorithm (YAER). The dataset covers 2011–2021 and includes AOD, fine mode fraction (FMF), single scattering albedo (SSA), Ångström exponent (AE), and aerosol type. The paper highlights improvements in spatial/temporal coverage and retrievals over challenging environments (clouds, coastlines) and provides validation against AERONET. Such a dataset will undoubtedly benefit climate, air quality, and health research in the region. The manuscript is generally well-structured, and the methods and results are clearly described. However, several issues require attention before publication.

Response: The authors would like to thank the reviewer for their time, comments, and suggestions. The criticisms and comments have helped us improve our paper. We did our best to answer the raised questions and clarify parts of the manuscript that were found to be unclear or ambiguous. Following, the authors prepared the responses, one by one to the addressed comments.

Major comments:

1. The manuscript notes that FMF, SSA, AE, and aerosol type are ancillary and “recommended for qualitative or interpretive use” due to uncertainty. However, the practical scientific utility of the dataset would be significantly enhanced by providing quantitative validation and uncertainty characterization for these variables (not just for AOD). Please include additional validation results for FMF, SSA, AE, and aerosol type where possible (even if only for selected periods/sites with ground truth), and discuss sources of error and their implications for users.

Response: We agree that the derived products are of good utility in aerosol characterization, and thus the quantitative validation results for the derived products should be included. The validations of FMF at 550 nm, SSA at 440 nm, AE between 440 nm – 870 nm to AERONET inversion V3 level 2 dataset are conducted. FMF at 550 nm of AERONET was calculated by dividing fine-mode AOD by total AOD at 550 nm obtained from quadratic interpolation of spectral AOD. The spatial and temporal collocation criteria are identical to those of AOD at 550 nm and only points with AOD > 0.3 for FMF and AE and AOD > 0.4 for SSA were used to ensure the necessary sensitivity for these variables (Choi et al., 2018).

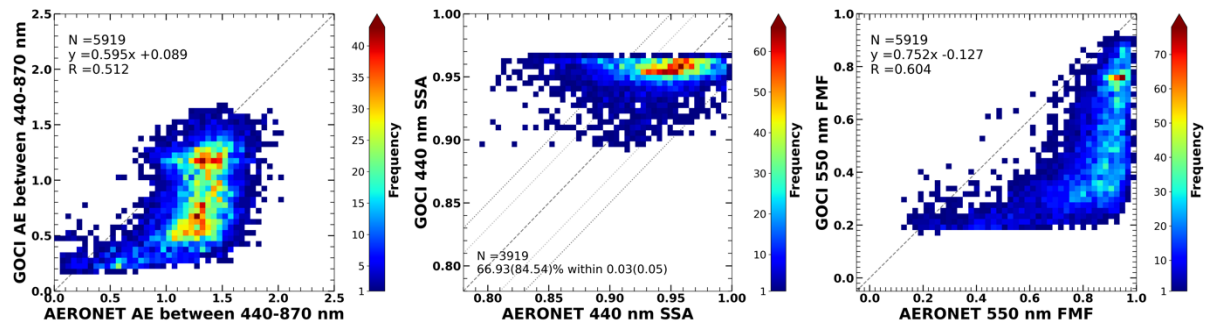


Figure A3. Validation of GOCI high-resolution YAER AE between 440–870 nm, SSA at 440 nm, FMF at 550 nm. For SSA, the % within ± 0.03 and ± 0.05 range are shown, and for FMF and AE, the correlation coefficients are shown.

Table A1. Confusion matrix of GOCI high-resolution aerosol type compared to AERONET during the whole observation period.

		GOCI high-resolution					
	Aerosol type	Dust	Non-absorbing coarse	Mixture	Highly-absorbing fine	Moderately-absorbing fine	Non-absorbing fine
AERONET	Dust	185	11	0	0	0	0
	Non-absorbing coarse	2	1	0	0	0	0
	Mixture	322	34	4	1	0	3
	Highly-absorbing fine	284	358	138	0	1	97
	Moderately-absorbing fine	405	548	644	0	64	687
	Non-absorbing fine	209	304	362	2	78	1174

As for the ancillary variables, the validation results are less promising compared to those of AOD at 550 nm. This is because these variables are ‘determined’ as the values saved in the LUT nodes that minimizes the standard deviation of AOD assuming each aerosol model. More specifically, the ancillary variables are calculated by mixing the top three weighted node values

that minimizes the standard deviation. Theoretically, if the TOA reflectance, radiative transfer model, the algorithm, and the LUT perfectly reflects the real world, the determined values would be identical to the true values (which is assumed as the AERONET values here). However, mainly due to errors in aerosol models and their assumed aerosol properties, the aerosol model that minimizes the AOD of each aerosol model may not always hold aerosol optical properties that the real world does. Here, the FMF of GOCI high-resolution products has underestimation issues over AERONET FMF > 0.6 and performs better at cases where aerosol particles are large (AERONET FMF < 0.4). The underestimation of GOCI FMF has led some fine-mode aerosols of AERONET classified into coarse-mode types of GOCI (Table A1). For SSA, majority of the collocations locate in where both GOCI and AERONET show values between 0.9 and 1. The accuracy of ancillary variables can be improved by developing an advanced algorithms focusing on these variables.

Nevertheless, to strengthen the value of the ancillary products, quantitative analysis on a severe dust case is conducted to provide an example for usage in quantitative analysis.

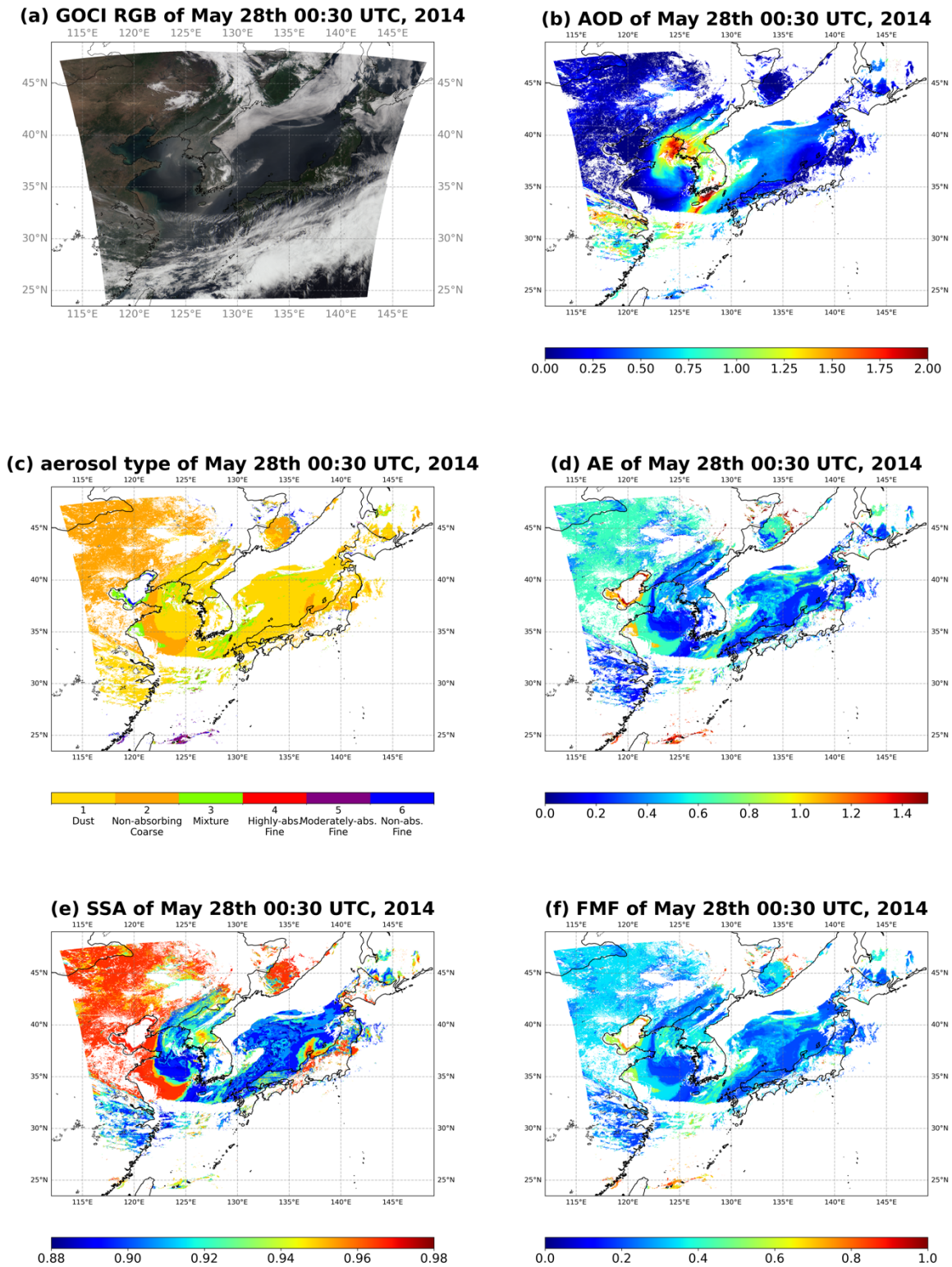


Figure A4. (a) GOCI RGB composite image and high-resolution (b) AOD, (c) aerosol type, (d) AE, (e) SSA, and (f) FMF products of May 28th, 00 UTC, 2014.

Fig. A4 shows a dust plume covering the Yellow Sea and the Korean Peninsula on May 28th,

2014, which is one of yellow dust cases identified by the Korea Meteorological Administration. Note that at points where AOD has a negative value, the ancillary variables are represented as NaN. Over the region where the dust plume is located, the aerosol type is mostly classified as dust, and some pixels were identified as mixture (Fig. A4c). Low AE and FMF values (Fig. A4d and A4f) indicate the coarse size of the aerosols included in the dust plume, and low SSA (Fig. A4e) indicate that these aerosols are less absorbing in 440 nm. However, it should be noted that because the ancillary variables are provided from pre-determined nodes, their spatial distributions are somewhat discrete. Overall, ancillary variables of GOCI high-resolution product may be useful for interpreting the relative size and scattering properties within the product, but the qualitative usage should be taken with care.

The qualitative validation and the quantitative case study, as well as the descriptions of ancillary variables are added to the manuscript (Section 3.2).

2. The authors describe an advanced cloud detection and removal scheme but do not provide a systematic assessment of residual cloud contamination, which is known to bias AOD retrievals, especially at high resolution. It would be valuable to compare the performance of the new cloud screening to that of standard (operational) products.

Response: We acknowledge the reviewer's concern; however, the cloud detection and removal scheme used in the high-resolution algorithm and the operational algorithm is identical, with no modifications. The reason for the pronounced fine-scale AOD between cloud structure is mainly due to the aggregation process where pixels of observation resolution are aggregated into the product resolution. Thus, the AOD details among clouds are not the results of advanced cloud detection but are from the higher product resolution. Residual clouds may be represented as high AOD, which are shown in Fig. 5, where some points have high GOCI AOD at low AERONET AOD.

As an alternative, comparisons with cloud products from other GEO satellites can be attempted; however, the high-resolution aerosol product only provides aerosol information, and pixels that are considered unsuitable for aerosol retrieval has been discarded. These discarded pixels include not only clouds but also contains overly bright surfaces, sun glints, and observation defects. Moreover, temporal differences between different satellites can lead to large discrepancies in cloud positions and distributions. Therefore, a strict apple-to-apple comparison of cloud detection is difficult to achieve.

To clarify, the description on cloud detection algorithm is more specified in Section 2.1.1, and the impact of cloud contamination has been described in Section 3.2.

3. While the validation of AOD against AERONET is comprehensive, the data show persistent underestimation at high AOD (>1.0) and overestimation over turbid water and sparsely vegetated land. The current discussion is brief. Expand the discussion on possible causes for these retrieval biases, such as surface reflectance a priori selection, aerosol model assumptions,

or radiative transfer LUT limitations. Suggest potential mitigation strategies, or at least clarify limitations for high-AOD and complex surface regimes.

Response: Figure 7a, 7b shows a persistent underestimation of high AOD and overestimation over turbid water and sparsely vegetated land. The underestimation of high AOD is primarily attributed to errors in aerosol model selection and the errors of assumed aerosol optical properties within the LUT. For example, because the non-absorbing coarse model is assumed from higher SSA compared to highly-absorbing fine type, if a highly-absorbing fine aerosol is mistaken as non-absorbing coarse type particle, the retrieved AOD would be lower. When validating aerosol type, some portion of highly-absorbing fine aerosols, which mostly arise from smoke and exhibits high AOD, were being mistaken as dust and non-absorbing coarse type (Table A1), which would have led to AOD underestimation.

Overestimation of AOD over turbid water and sparsely vegetated land is mainly due to the errors of surface reflectance a priori selection. Both surfaces are bright over visible spectra. This indicates that for these bright surfaces, the minimum reflectance technique has limitations, and vegetation should be considered in calculating the surface reflectance.

The description on the limitations and possible causes for the biases has been expanded (Section 3.2, Line 316).

4. While the manuscript references related studies and datasets (e.g., MODIS, VIIRS, GEMS), a direct comparison with other existing satellite AOD products over the same region and period (where possible) would further contextualize the strengths and weaknesses of the new GOCI dataset. It should provide a comparative assessment (statistical metrics, spatial patterns, or time series) between your dataset and other satellite or reanalysis products (e.g., MODIS MAIAC, VIIRS DB, GEMS) to demonstrate added value and highlight specific improvements or tradeoffs.

Response: Figure A5 shows a validation of GOCI high-resolution AOD, MODIS MAIAC AOD, and VIIRS Deep Blue AOD to AERONET AOD during 2015. The spatial resolution of MODIS MAIAC and VIIRS Deep Blue AOD are 1 km and 6 km, respectively. The AOD of 04 UTC, which is approximately 01 UTC over Korea and Japan, is also validated for comparison with LEO satellites. GEMS was not included in the analysis because the observation period of GEMS (November 2020–) and GOCI (–March 2021) overlap for only a short time.

The GOCI high-resolution products have a comparable validation metrics compared to MODIS MAIAC and VIIRS Deep Blue, with a slightly higher error. Despite the error, the prevalence of high AOD pixels of GOCI within EE implies that high AOD plumes frequently went undetected in MODIS and VIIRS, where temporal resolutions are lower. Therefore, using GOCI AOD for air quality analysis can more closely reflect the transport and distribution of aerosols over East Asia.

The description and Fig. A5 has been added to Appendix A.

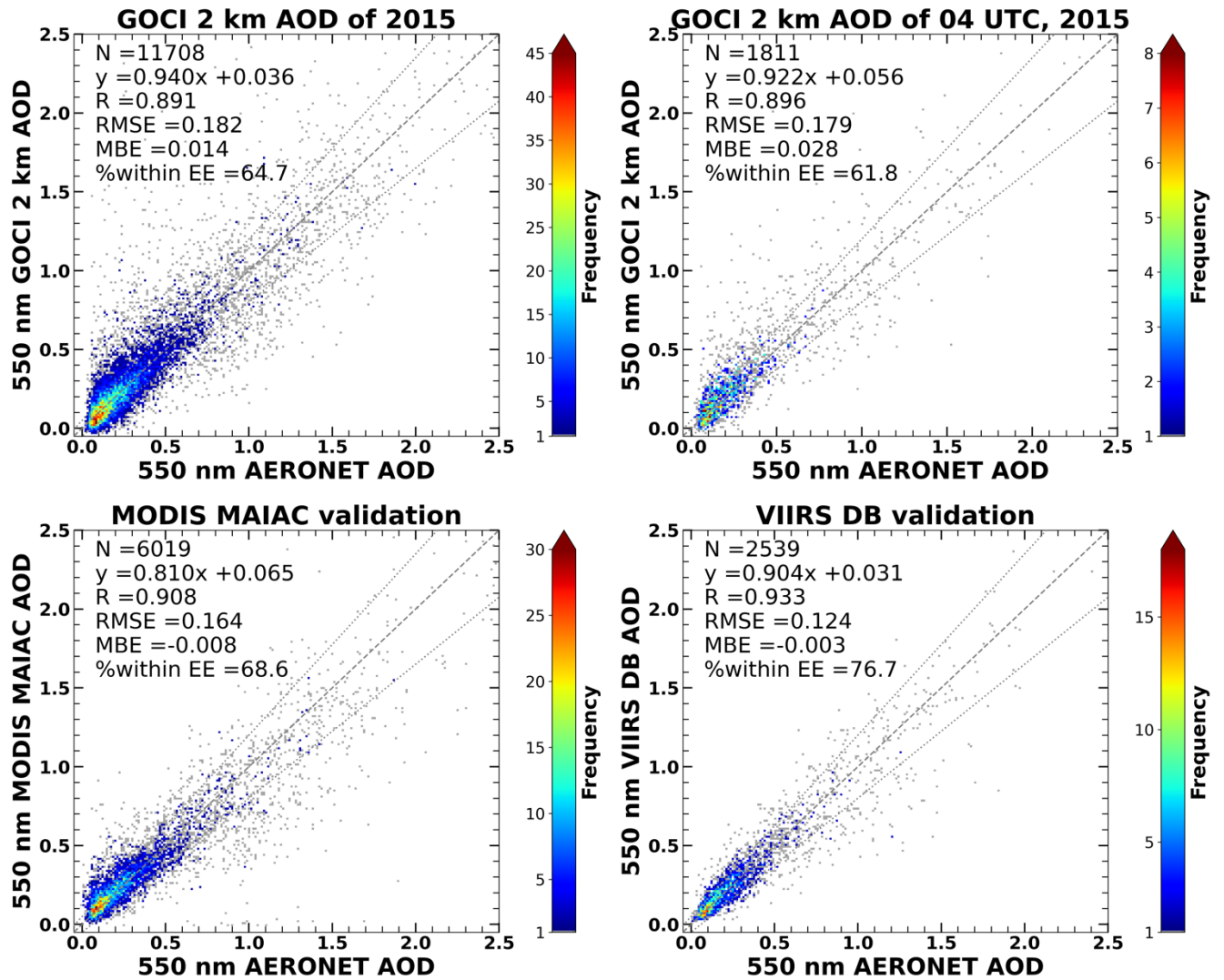


Figure A5. Validation of GOCI high-resolution AOD, MODIS MAIAC AOD, and VIIRS Deep Blue AOD of 2015 to AERONET AOD.

Minor comments:

1. Please clarify how gaps due to clouds, sun-glint, or other data removal are handled (e.g., are missing values flagged, interpolated, or left as NaN?).

Response: The removed pixels are left as NaN. The description has been added in Section 2.2, Line 201.

2. Improve the clarity of several figures (e.g., Figures 2–4): add scale bars, colorbars, and clearer labeling for readers less familiar with the region.

Response: Figures 2–4 are revised to have a clearer labelling and information.

References

Choi, M., Kim, J., Lee, J., Kim, M., Park, Y. J., Holben, B., ... & Song, C. H. (2018). GOCI Yonsei aerosol retrieval version 2 products: an improved algorithm and error analysis with uncertainty estimation from 5-year validation over East Asia. *Atmospheric Measurement Techniques*, 11(1), 385-408.