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.

Reviewer 1

This study generates a decade-long (2011-2021) high-resolution aerosol dataset for East Asia using GOCI satellite observations and radiative transfer modeling. The dataset provides robust hourly aerosol optical properties, including aerosol optical depth (AOD), fine-mode fraction (FMF), single-scattering albedo (SSA), Ångström exponent (AE), and aerosol classification. These products are particularly valuable for climate and environmental research communities in improving weather forecasting and air pollution monitoring. While the dataset meets ESSD standards for long-term aerosol records, the manuscript requires major revisions to address some comments 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.

The GOCI satellite's native 500 m spatial resolution provides unique advantages over other geostationary satellites (e.g., Himawari-8/9, MSG-R, GOES-R) for aerosol monitoring at finer scales. However, the decision to upscale to 2 km resolution - while improving retrieval robustness through pixel grouping - potentially diminishes this competitive advantage. The comparative analysis presented in the study actually demonstrates the superior capability of higher-resolution observations, making the 2 km resolution choice appear scientifically questionable.

Response: We understand the questions arising from selecting 2 km as the retrieval resolution instead of the 500 m observation resolution. While products with high resolution provide the users the information on a finer scale, there are tradeoffs caused from the high resolution. The current 2 km resolution was decided considering the balance between the fine-scale information and its product accuracy.

The tradeoffs of AOD retrieval on the observation resolution can be listed as follows.

First, the stability of retrieval is reduced due to reduced signal-to-noise ratio, increased 3-D cloud effects, and vulnerability to radiometric noise. As stated in Section 2.1.1, the brightest 60% and the darkest 20% of the observed pixels are discarded during the aggregation process, to account for artifacts including cloud 3-D effects and cloud shadows. Thus, using pixels that meet the cloud masking criteria directly for retrieval without aggregation can introduce biases in the resulting AOD. Due to these considerations, many widely used algorithms choose to generate aerosol products at spatial resolutions coarser than the native ground pixel resolution, even when developing a high-resolution counterpart of an existing operational product (Remer et al., 2013; Sayer et al., 2018).

In addition, although higher spatial resolution can theoretically enhance detail, for the primary end-users of this product, the associated increase in retrieval uncertainty stated above often undermines its benefit, offering limited added value in the context of the intended applications. Due to these reasons, we selected 2 km as the optimal retrieval resolution for this product.

The description above has been added to Section 2.1.1.

Nonetheless, we fully acknowledge the unique value of higher spatial resolution. As such, we noted in the conclusion that foreseen algorithmic advancements (e.g., improved noise filtering, incorporation of machine learning (ML) or deep learning (DL) techniques) may allow for reliable operational retrievals at a higher resolution, which can be addressed in a future work (Section 5).

While AOD validation is thoroughly presented, the derived products (FMF, SSA, AE) lack equivalent validation despite their scientific importance. These parameters should receive proper quantitative evaluation given their utility in aerosol characterization.

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).

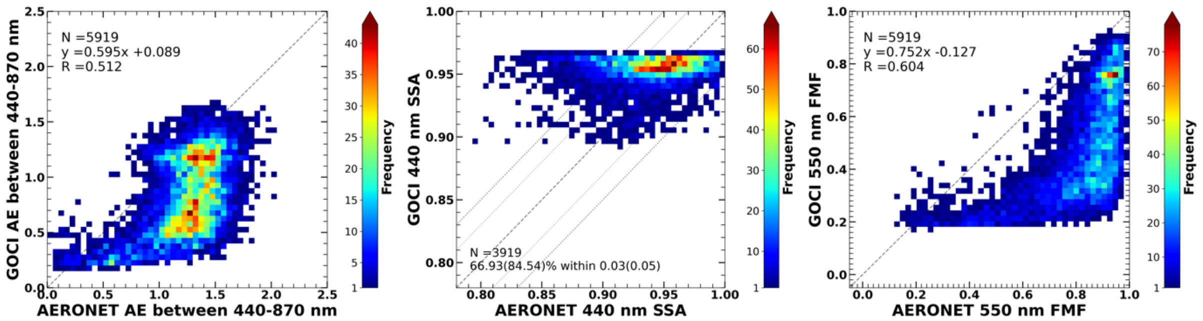

Figure A3. Validation of GOCI high-resolution YAER AE between 440–870 nm, SSA at 440 nm, FMF at 550 nm. For SSA, the % within ±0.03 and ±0.05 range are shown, and for FMF and AE, the correlation coefficients are shown.

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.

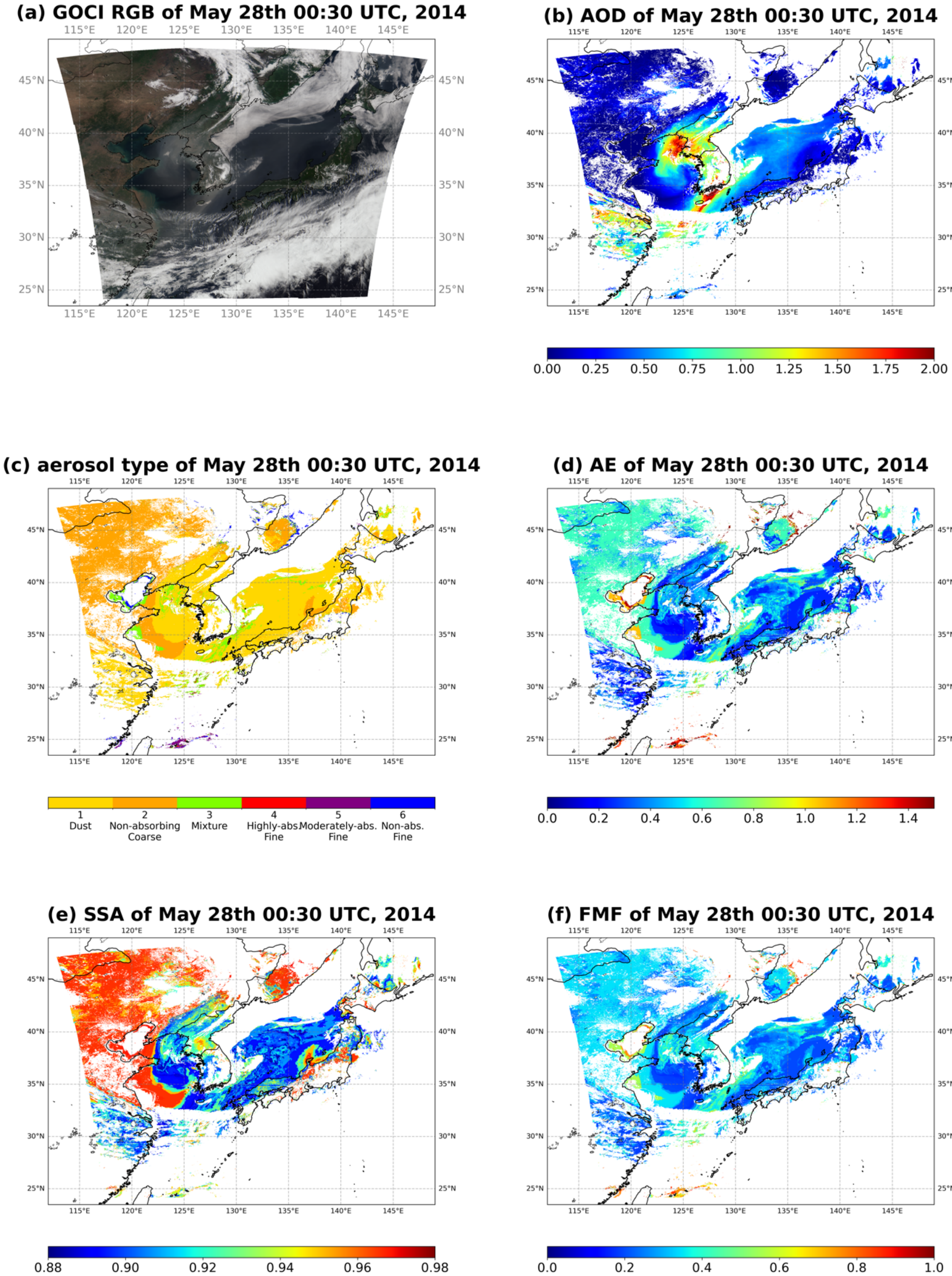

Figure A4. (a) GOCI RGB composite image and high-resolution (b) AOD, (c) aerosol type, (d) AE, (e) SSA, and (f) FMF products of May 28th, 00 UTC, 2014.

Fig. A4 shows a dust plume covering the Yellow Sea and the Korean Peninsula on May 28th, 2014, which is when yellow dust was 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).

The figures and tables require significant improvement.

Response: The figures and tables were improved according to the comments.

Specific comments:

1. Line 95, the advantage of GOCI, including its visible spectrum, long-term observation records with stability, and the presence of a successor satellite, is not fully shown. The developed retrieval algorithm uses only limited bands rather than the full spectrum. Compared to GOCI, the MSG satellite series have longer observation records and multiple successor satellites.

Response: Owing to its multiple visible bands, GOCI can efficiently separate the signal between the atmosphere and the Earth surface. In addition, the long-term records of aerosols can be obtained when a product from a same algorithm of a successor satellite exists. These advantages are more clarified in Section 1, Line 100.

The inversion is divided into three parts: land, ocean, and turbid water. The wavelengths used for each part is decided based on their stability on separating the signals between the surface and aerosol. For land, wavelengths 412 to 680 nm are used, because the two NIR wavelengths have a higher surface reflectance and thus may cause uncertainties in separating the signals between the land surface and atmospheric aerosols. For ocean and turbid water, the green and red channels are excluded due to their high water-leaving radiances. Overall, all eight bands are incorporated in the retrieval algorithm. The description on wavelength selection was added in Section 2.1.3, Line 177.

While other GEO satellites that have a longer observation records and multiple successor satellites exists, GOCI has its unique values on 1. observes East Asia, where aerosol loadings have been a big concern during the past decade, 2. has a reliable accuracy in terms of AOD. The existence of GEO satellites for other regions of the world, and the value of GOCI for watching East Asia is added in Section 1, Line 73. The existence of a successor satellite, GOCI-II, and the potential value of comprehensive usage of the GOCI series has been described in Section 5.

2. Line 125, how is the cloud threshold determined? Only three tests are used—is this too few? And how is the water detection threshold used? Confirm whether they align with the operational algorithm's implementation.

Response: While the cloud detection schemes can be roughly classified into three, which are TOA reflectance threshold test, reflectance ratio test, and the 3 × 3 pixel standard deviation and mean test, there are multiple wavelengths and ratios that are considered. Total of eleven tests are applied for cloud masking over land and ocean combined. The thresholds are determined based on the references of each cloud detection scheme considering its compatibility to GOCI. The cloud detection thresholds and criteria of the high-resolution algorithm aligns with that of the operational counterpart. The details have been added to Section 2.1.1.

3. Lines 140-145, the minimum reflectance technique often leads to underestimation of surface reflectance since no day can truly be aerosol-free, even if it is very clean.

Response: The 5-year period provides plenty of observations to find a clear scene, but it should be noted that no day can truly be aerosol-free, and the least amount of aerosol present in the 'clear scene' may cause a marginal overestimation of surface reflectance. The overestimation of surface reflectance occurs because the minimal aerosol reflectance of a clear day would be attributed to the surface reflectance, leading to a higher RCR compared to the real world. The error source of surface reflectance database was added to Section 2.1.2, Line 156.

4. Line 155, define and explain the look-up table (LUT) methodology for readers who may be unfamiliar with this technique, despite its common use in the field.

Response: The definition and explanation of the LUT methodology was added in Section 2.1.3, Line 170.

5. Figure 4, why are the gaps different between the two?

Response: The pixels excluded from retrieval are different for high-resolution products and operational products because of the aggregation process. The respective 6 km pixels including the Han River were not screened out because although the inland water pixels in the observation resolution were masked out successfully, the adjacent land pixels within the same 6 km pixel met the aggregation criteria. In other words, some pixels that are included in the operational product but not retrieved in the high-resolution product may result from a mixture of valid and invalid observation resolution pixels. These mixed pixels may fail to meet the threshold for merging in the high-resolution retrieval but are included in the coarser operational resolution, which is merged from a greater number of pixels. As a result, certain pixels in the operational product may reflect signals from only a very small portion within the 6 km area. Therefore, it can be inferred that the 2 km products effectively eliminate the influence of inappropriate pixels in fine geographical features. The description regarding the difference has been supplemented in Section 3.1, Line 260.

6. Line 255, the uncertainty of AERONET AOD should be updated based on the latest studies.

Response: Thank you for pointing this out. According to Sinyuk et al. (2020), the uncertainty of computed AOD, mainly due to calibration uncertainty, is ~0.010 – 0.021 for field instruments (where the high errors are from UV). We updated the description of AOD uncertainties according to this reference.

7. Figure 6, why are only R, EE, and MBE shown?

Response: To strengthen the analysis, three additional parameters, MAE, RMSE, and number of collocated records (N) are added to Fig. 6.

8. Line 320, the time-series AOD changes (Fig. 9) should be explained in more detail, as they appear very interesting, particularly the intra-annual variations.

Response: The details of time-series AOD are analyzed in depth. The decreasing trend and the p-value of the trend of each city is calculated. Furthermore, the correlations between the four cities are analyzed. While there are some intra-annual variations, several factors such as dust outbreaks, wildfire aerosol plume transports, cloud coverage, meteorology and monsoons may have influenced the trends. The enhanced analysis within the scope of data description was added.

9. I encountered difficulties accessing the dataset (https://doi.org/10.7910/DVN/WWLI4W) during my review. Could this be due to regional access restrictions in China, or is there another technical issue with the data repository?

Response: Thank you for pointing out. We tested the access availability of the repository in multiple countries and found out that for some countries, the access is restricted. We re-uploaded the dataset to a different repository and the manuscript was updated accordingly (https://doi.org/10.5281/zenodo.16656274).

Technical corrections:

1. Table 1, suggest to improve by maintaining consistent line spacing throughout all paragraphs in the table.

Response: The line spacing of Table 1 is rearranged.

2. Figure 1, the city legend is missing and should be included.

Response: The city legend was updated.

3. Figure 3 requires descriptive titles and proper labels for each subplot.

Response: The UTCs, spatial resolution, and the observation date of each subplot were labeled.

4. Figure 4, a legend identifying the sites should be provided, and the figure appears excessively long and could benefit from resizing or reorganization.

Response: The legend is added, and the figure is resized.

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.

Remer, L. A., Mattoo, S., Levy, R. C., & Munchak, L. A. (2013). MODIS 3 km aerosol product: algorithm and global perspective. *Atmospheric Measurement Techniques*, *6*(7), 1829-1844.

Sayer, A. M., Hsu, N. C., Lee, J., Bettenhausen, C., Kim, W. V., & Smirnov, A. J. J. O. G. R. A. (2018). Satellite Ocean Aerosol Retrieval (SOAR) algorithm extension to S-NPP VIIRS as part of the “Deep Blue” aerosol project. *Journal of Geophysical Research: Atmospheres*, *123*(1), 380-400.