Referee #2

We appreciate the referee's insights and helpful comments/suggestions, which helped improve the scientific quality of our manuscript. Basically, we reflected all the comments and suggestions. And, newly added references were in revised manuscript.

1. General comments

The study validates and compares aerosol property, aerosol optical depth (AOD), of several satellites both GEO and LEO with AERONET or each satellite. The paper shows AOD accuracy of both GEO and LEO and indicates why the bias difference occurs. This study is useful to know what bias they have, to improve the retrieval algorithms and to select AOD data for air quality models. Below are my comments for the authors to consider before publishing the paper.

2. Comments

(1) The paper mentions about using satellite combined AOD for air-quality model and mentions that an observation campaign in the paper also lead to improve air quality model. Please added some sentences what problem of present models has (only for high time resolution?). Why combined AOD using GEO and LEO is useful (than that using only GEO)?

Ans.) Relevant section of manuscript was revised as below.

To improve air quality model accuracy through satellite AOD retrieval, the satellite AOD should have broader coverage, high spatiotemporal resolution, and high accuracy. Most

AOD data assimilation system has been developed by using LEO satellite products such as MODIS because they have global coverage and high accuracy through the continuous retrieval algorithm improvement. The GEO satellite can provide more frequent AOD, but its spatial coverage can be limited to the specific area, especially in the case of GOCI. The period of AOD retrieval algorithm development and investigation using GEO is relatively shorter than LEO. Also, generally LEO sensors have more suitable channels with high resolution and advanced measurement characteristics such as multi-angle and/or polarization for aerosol retrievals, which could result in higher accuracy of AOD from LEO than GEO generally (Jiang et al., 2019). Therefore, both accuracy and spatiotemporal coverage can be obtained simultaneously by using combined GEO and LEO AODs. For these reasons, the demand for GEO aerosol measurements is high.

(2) In the abstract, the author has said that cloud screening is AOD difference between sensors. However, it is difficult to understand it from the paper. Please tell me why you did not meet the condition of each cloud screening when you compare AODs from several satellite.

Ans.) The words of "plus differences in pixel screening" were deleted in the revised manuscript.

Each aerosol retrieval algorithm has different threshold for pixel masking. Some algorithms which aim to retrieve more AOD pixels despite of increasing error due to contamination can set their threshold of pixel masking loosely. In contrast, some other algorithms can focus on the high accuracy as sacrificing pixel numbers. And one example of this pixel masking is cloud masking. Generally, each aerosol product provides AOD value with subjective quality *assurance flag such as "best quality", or "moderate quality". Each algorithm has different method and threshold to detect cloud thus it is very difficult to analyze cloud screening impact on the validation. Also, AERONET only provide AOD with cloud-free condition regionally so that comparison between AERONET and satellite AOD is already clear condition. The best approach was to select "best quality" AOD pixels based on provided subjective quality flag.*

(3) Please add line between wavelength and the vertical line of MISR in Figure 1b (or remove lines between points). Please explain why MISR AOD accuracy is not good when MISR AOD is large over Land if you have some opinion. Please modify the figure because error bar is not clear.

Ans.) Because of the small number of MISR ocean AOD validation (15), the MISR points are not grouped in to 7 bins as others. The lines of others are getting longer from low AERONET AOD to high AOD as the sampling number is decreased but it doesn't work for MISR ocean AOD. Instead, the symbol of MISR ocean AOD is changed as dots compared to other triangles.

It was hard to say MISR AOD is not good when AOD is large over land because the points are also within expected error range [black broken lines representing $\pm$ (0.05 + 0.15 $\times$ AERONET AOD)] as others. Nevertheless, possible reason of MISR land AOD uncertainty in high AOD case can be from its retrieval approach. Most other retrieval algorithms except for MODIS MAIAC use pre-assumed surface reflectance using the relation between visible and SWIR channels or from the minimum reflectivity of composite dataset. It means that even high AOD case which is hard to see surface signal in visible they can retrieve AODs.

However, MISR aerosol retrieval algorithm actually targets simultaneous retrieval of surface bidirectional reflectance and aerosol signals from nine-angle and four channels (446, 558, 672, and 866 nm) measurement. Because it doesn't have SWIR channels and doesn't use any pre-calculated surface reflectance, the algorithm doesn't calculate AOD if aerosol signal is too high to get surface signals together. The range of MISR AOD product is set as from 0.0 to 3.0 according to Witek et al. (2018). The maximum value is lower than others such as 3.6 of GOCI and 5.0 of MODIS. This can be found from the validation with AEORNET in Fig. 10 of the revised manuscript. The high MISR AOD points collocated with AERONET are not as much as high than other products.

And the error bars are removed as your comment.

(4) Page 9, line17: "highly accurate", this expression is ambiguous. Please add what accuracy AODs are. In Page9: Does GOCI use Cox and Monk method over ocean? The AOD result of GOCI over ocean has positive bias, but in sentence the author have said "negative bias". Is it correct?

Ans.)

The sentence was revised as below.

In summary, most LEO and GEO aerosol products over East Asia are highly accurate based on a comparison with AERONET with high R (0.84–0.93) and low RMSE (0.12–0.17), but have unique bias patterns related to the surface-reflectance assumptions in each algorithm.

And, GOCI use Cox and Munk method over dark ocean. The "negative bias" of ocean AOD is for low AOD case around 0.1. And it changes to positive bias when AERONET AOD is *greater than 0.2 as in Fig. 3b of the revised manuscript, and results in total MB of 0.03 as in Table 5 of the revised manuscript. Although the biases of them are called as positive or negative, the quantities are small.*

(5) Figure 3. Please explain why MODIS DT and DB overestimate AOD.

Ans.) Below paragraph is added to the revised manuscript.

It is very hard to figure out exact reason of overestimation of MODIS DT, DB, VIIRS, and MAIAC AOD over this plume despite reasonable accuracy from AERONET validation. The statistical metrics of MODIS DT, DB, MAIAC, and VIIRS validation at Hokkaido University site during the campaign show very high R (0.96-0.98) and small offset of linear regression equation (–0.03 to 0.03) but higher slope than one (1.22–1.43) reveling high MB (0.12–0.18). Small offset of linear regression equation represents lower surface reflectance error in AOD validation. With this condition, higher slope generally means that AOD overestimation due to the aerosol model assumption generally (Hyer et al., 2011) if cloud masking is working well. This transport case results in also high AOD, where uncertainty of aerosol model can be emphasized. Therefore, possible reason of overestimation is due to an aerosol model assumption such as microphysical properties.

(6) Page10, line15~: "high accuracy", this expression is ambiguous. Please explain why accurate it is, and why GEO results have continuous spatiotemporal distribution.

Ans.) The paragraph was revised as below.

It can be summarized that overall evaluation is not matched with individual site or case over East Asia because of complexity of surface condition and dynamic aerosol types. Additionally, MODIS and VIIRS do not provide spatially continuous AOD distributions because of sun-glint masking over ocean areas near Hokkaido, making identification of plume sources and transport pattern difficult. In contrast, GEO can avoid sun-glint area over mid-latitude area. Sun-glint is a bright ocean surface due to the reflected solar radiance, which is brighter in nadir viewing angle. Due to the measurement geometry, single-angle viewing LEO sensors such as MODIS and VIIRS have the sun-glint pixels in the middle of swath generally. In contrast, GEO has the sun-glint pixels as a circle shape centered at equator because GEO sensors are located at the equator. Because of multi-temporal measurement without sun-glint pixels, GEO such as GOCI and AHI can detect these transported aerosol plumes across ocean with more continuous spatiotemporal distribution than LEO.

(7) Figure 4, 5: I think that it is good to add some discussion including the wind speed.

Ans.) Zonal wind at 850 hPa data is added in Fig 7 of the revised manuscript.

(8) Please correct to correct one. Page8 linr8-9, "... between 2011 and 2014 ... negative bias 2015", page13 line29-30, "... period 2011-2015 ... during the 2016"

Ans.) It was corrected as "*The climatological surface-reflectance database of GOCI did not show significantly negative biased AOD between 2011-2015 according to the validation study of Choi et al. (2018). This negative bias in 2016 may be due to a sensor calibration issue or degradation, but the exact cause is difficult to diagnose and remains unknown.*" And

"*Although Choi et al. (2018) showed that GOCI AOD is reliably accurate for the period 2011–2015, it is negatively biased during the 2016 campaign period. This difference in accuracy may be attributable to changes in climatological surface reflectance or calibration drift. Improvement of surface reflectance including these calibration drift or surface reflectance change is required.*"

References

Choi, M., Kim, J., Lee, J., Kim, M., Park, Y.-J., Holben, B., Eck, T. F., Li, Z., and Song, C. H.: GOCI Yonsei aerosol retrieval version 2 products: an improved algorithm and error analysis with uncertainty estimation from 5-year validation over East Asia, Atmos Meas Tech, 11, 385-408, 2018.

Hyer, E. J., Reid, J. S., and Zhang, J.: An over-land aerosol optical depth data set for data assimilation by filtering, correction, and aggregation of MODIS Collection 5 optical depth retrievals, Atmos Meas Tech, 4, 379-408, 2011.

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