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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Improvements in AOD retrieval from geostationary measurements over Asia with aerosol optical properties derived from the DRAGON-Asia campaign" *by* M. Kim et al.

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Comments from the Reviewers: The reviewer's comments and suggestions were precise and helpful to improve the scientific contents of the manuscript. We appreciate the efforts by the reviewer and editor. Basically we reflected all the comments and suggestions by the reviewers.
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Reviewer #2:

General comments

The title is misleading. Although Seoul and Osaka are situated in Asia, the aerosol models applying over these regions are unlike to apply over all Asia and hence cannot contribute to retrieval improvement over Asia, only over part of SE Asia. As explained in my comments below (detailed comments, 10788), the improvement in the AOD retrieval is questionable. The goal of the paper is to improve the single channel retrieval algorithm applied to MI to retrieve AOD, as mentioned the title and the discussion. The study builds on earlier work by Kim et al. published in RSE in 2014. Since the retrieval method is key to the work described here, the authors should provide a brief summary how a single channel algorithm can be used for aerosol retrieval, what the assumptions are, what the status was before this study, and what improvements are made in the current paper with respect to the previous work. In particular, with only a single channel available, only one parameter can be retrieved of the many which determine the radiance at the top of the atmosphere observed by the instrument. Since the parameter the authors are after is the AOD, all other parameters have to be assumed or estimated. How well is this done and what are the implications due to uncertainties in the assumptions?

- The title was changed to "Aerosol Optical Properties Derived from the DRAGON-NE Asia campaign, and Implications for a Single Channel Algorithm to Retrieve Aerosol Optical Depth in spring from Meteorological Imager (MI) On-board Communication, ocean, and Meteorological Satellite (COMS)", to clarify that this study focused on the effects of the DRAGON-NE Asia campaign to AOD retrieval algorithm using satellite measurement. The focus was shown in lines 116 -118. - Since the detail of the single channel algorithm was described in section 3, short introduction of the algorithm was shown in lines 118-124 in the revised manuscript. An addition, difference between the algorithms shown in the Kim et al.(2014) and in this study was described in lines 133-146. - As per the reviewer's suggestions, the uncertainties in the AOD retrieval related with other assumed parameters were added in section 3.5 in the revised manuscript.

The authors put a large emphasis on the improvement of the aerosol model used in the

retrieval, in particular they use data from the DRAGON-Asia campaign in 2012. Since this campaign had a limited duration (3 months), how do these data apply to the rest of the year and what has been done to extend for the full year? How are seasonal variations taken into account (Tables 2 and 3, bottom)? How can the results in these tables change for other seasons than those for which DRAGON was deployed? Seasonal variation appears to be an input parameter to the retrieval! Especially because the authors mention that the largest improvement was due to the use of the DRAGON campaign, while the use of an extended time series of other sun photometers with 2 more years made hardly any difference (10783, 15-21). This would imply that the aerosol properties over Asia had hardly changed over these years.

- As per the reviewer's suggestions, the Table 2 and Table 3 were updated as Table 2 in the revised manuscript. To avoid confusion, the values for other seasons were removed in table 2, and the description about the AOP changes were revised in lines 353-370. In lines 370-380 in the revised manuscript, changes in volume size distribution and refractive indices were mentioned, also. - Lyapustin et al. (2011a) shown that the SSA in eastern China increases from 2000 to 2010 by about 0.02 at 470nm The change corresponds with the increase of average SSA by 0.005 from 2010 to 2012. In addition to the SSA increase, changes in particle size distribution and refractive indices were found in the expended inversion dataset. This study focused on the effects of the change on the AOD retrieval using single channel algorithm.

How does the single channel algorithm select the aerosol model? How are spatial variations taken into account? In Tables 4 and 5 I see validation statistics for 39 sites but it is hard to believe that the aerosol models are invariant over the wide area considered in the study (cf. Figure 1: 15x10 degrees!) For example, Figure 3 shows a very strong variation in the average AOD and AE over the study area which strongly indicates that the aerosol models vary spatially. I'd also like to see how the measured (AERONET & DRAGON) and derived (model) compare, in particular how well do the derived properties describe spatial and temporal variations during the DRAGON campaign and over

the long time series (cf. Table 1). How representative was the DRAGON period for the whole time series?

- The biggest limitation of the single channel algorithm is in the selection of aerosol type. Thus the algorithm focused on the optimization of the aerosol model to represents dominant state of aerosol properties over North East Asia. The limitation was mentioned in lines 122-123, and uncertainty related with the limitation was shown in Figure 6 in section 3.4. Because of the limitation in detection of temporal and spatial variation of aerosol type, the comparison of retrieved products with AERONET AOD shows different statistics depending on location and time. The locational difference was shown in Table 3, 4 and lined 631-666. In Figure 11 and lines 645-657, the DRAGON AOD and the MI AOD were shown by time series to show more detail of the spatial and temporal correlation.

An aerosol model is described by a size distribution, preferably multi-modal to take into account at a minimum the fine and coarse mode fractions, plus the imaginary refractive index for each mode. However, the authors only report the real and imaginary parts of the refractive index which makes it impossible for others to use their results. I see no metrics indicating a measure of the quality of the model parameters as obtained from the analysis, i.e. what is the accuracy with which the real and imaginary parts of the refractive index are obtained? In 10792, 27 is mentioned that the use of the DRAGON data resulted in an increase of SSA of 1.1% while a few lines below (10792, 4) they mention that the assumed SSA error is 3% resulting in an AOD error of -20% to +23% for the situation given in that para. Furthermore, since the authors don't provide the particle size distribution, it is impossible to estimate the effect on the SSA of a change of about 0.001 in the imaginary refractive index, combined with a change of about 0.01 in the real part.

- As per the reviewer's suggestion, Table 2 and Figure 5 were edited to describe about volume size distribution. In the table, the standard deviation of analyzed refractive index and number of compiled dataset were shown also.

As mentioned previously, the description about the changes in volume size distribution was shown in lines 372-380 in the revised manuscript. - We used quality assured dataset by following criteria suggested by AERONET science team (http://aeronet.gsfc.nasa.gov/new_web/Documents/AERONETcriteria_final1_excerpt.pdf), but the accuracy of the complex refractive index was not evaluated here. Instead, standard deviation of analyzed refractive index was described in Table 2. - The sensitivity test with 4% SSA variation was conducted to cover the standard deviation of compiled SSA as revised sentence in lines 402-403.

Another issue is the wavelength dependence. Where AERONET provides data in discrete wavebands, the MI measures in a single VIS waveband (0.55-0.80 micrometer). How is the variation of the aerosol optical properties over this quite broad band accounted for? How is AOD at 550, as reported e.g., in Fig. 8, obtained?

- The conversion of AOD was mentioned in lines 349-353 in the revised manuscript.

The authors write several times that a goal of their work is to improve their understanding on the aerosol optical properties over the study region (e.g. 10791, 5 and 21). However, they don't report what in their understanding has improved, what have they learned from this study? They only report changes in the numbers they use to describe the aerosol properties, and correlations.

- As mentioned in lines 116-118 in the revised manuscript, the goal of this study lies on understanding the effects of AERONET measurement campaign to the AOD retrieval algorithm. The phrase in lines 104-107 describes a general role of the ground-based measurement in the satellite-based aerosol measurement. Though the AOP change was insignificant, this study showed the effects of the AOP assumption to AOD retrieval utilizing single channel algorithm. Nonetheless, the limitation of the algorithm in the aerosol type selection and BAOD assumption increased the uncertainties in AOD.

For these and other reasons summarized below, the manuscript is not ready for publication in ACP. Major revision and a second review are required. I further suggest thor-

ough proofreading: I noticed several sentences which should be corrected (e.g.10790, 13-16, see also minor comments), and some references are missing (e.g. Frey et al. 2008; Kim et al., 2015; Choi et al. 2015; there may be more, I checked only a few).

- As per the reviewer's comments, several sentences were corrected throughout in the revised manuscript. The Kim et al. 2015 is in preparation and the Choi et al. was accepted by AMTD in July, and was updated in the reference list. There was a mistake during type setting process. All of the references were checked again, and revised in the revised manuscript.

Minor Comments

10775, 10-15: I miss here the more recent retrieval improvements, in particular for LEO there are no references after 2010 for, e.g., MODIS (C6), MISR, SeaWiFS or European efforts (AATSR, MERIS), which all have significantly improved over the last 5 years and provide similar validation metrics.

- The reference list was updated in lines 74-76 in the revised manuscript.

10775, 16-20: surface reflectance can be accounted for using dual (AATSR) or multiple (MISR, POLDER) view algorithms, or for single view algorithms using certain assumptions (MODIS) or modelling approaches.

- The approaches to estimate surface reflectance was edited in lines 84-89 in the revised manuscript.

10776, 5, 6: references are needed for each statement

- Relevant references were added in lines 105 and 107 in the revised manuscript.

10776, 22: which satellite algorithm?

- The phrase was revised as lines 114-115 in the manuscript.

10776, 24: I think this study would better be done for a multi-channel algorithm? Hence

some justification is needed for using a single channel. The sensitivity of a single-channel algorithm to the assumptions in AOPs (10776, 28) is not explicitly tested. Only improved statistics from using an improved aerosol model are presented, but I see no explanation where this improvement comes from. (see also general comments)

- The multi-channel algorithm was tested by using GOCI measurement, but the effect was insignificant than that shown in this study. That was mentioned in lines 744-748 in the revised manuscript.

10777, 5: typo

- The sentence was revised by lines 138-140.

10777, 7: when an aerosol model is representative, how can it be improved?

- The description about the important of the aerosol model assumption was edited in lines 124-126 in the revised manuscript.

10777, 14-end of para and Section 3.1: it seems awkward to use a minimum reflection method over a heavily polluted region like SE Asia, cf. the AOD values in Figure 2. The BAOD most likely has a substantial contribution to the total TOA radiance. How can this ever result in a realistic surface reflectance value? Most likely uncertainty in surface reflectance has a much larger influence on the retrieved AOD than the choice of the aerosol model, or tweaking the aerosol model as done in this MS. This method should be evaluated for the study area before it can be applied in the retrieval study.

- The uncertainty in surface reflectance related with BAOD assumption was analyzed in section 3.5 (lines 477-495 and Figure 7(c,d)). The sensitivity of AOD error to error in surface reflectance was shown there. The test shown that the error in surface reflectance is significant for low AOD condition, while the error in aerosol model has great role in high AOD condition. The limitation of the BAOD correction was shown in lines 749-753 in the revised manuscript.

Section 3.1 discusses the BAOD which ranges from 0 to 0.56, as determined from 7

years of MODIS AOD data. But how do these and other numbers connect with the numbers in Figure 4 which shows a maximum BAOD of 0.3 as the 'absolute minimum AOD' (caption) rather than an average value (10782, 6). I wonder about the representativeness of the surface reflectance data determined using the BAOD for atmospheric correction. The result is at best an average for these 7 years, but does not take into account year-to-year, seasonal or other temporal variations. Hence large surface reflectance errors are likely to result and hence large errors in the retrieved AOD.

- Figure 4 was changed to cover the BAOD variation between 0.0 and 0.6, and the description was revised in lines 304-308. The inconsideration about temporal variation of the BAOD was mentioned in lines 239-243.

10778, 20-end of page: needs some proofreading: 'was decreased', 'values of Japan', 'AE represents the change of particle size', 'where'

- As per the reviewer's comment, the paragraph in lines 186-190 was revised.

10778, 25: I see AE changes from blue (1.1) to red (1.4): these are certainly not 'not significant' changes in particle size distribution.

- The sentence was removed in the revised manuscript.

10779, 10: likely the authors mean that they kept part of the data apart from the model analysis and used them only for validation. Please reformulate this sentence.

- The sentence was reformulated in lines 204-206 in the revised manuscript.

10780, 11: one-to-one relationship between two variables: what do you mean: which variables?

- The phrase was revised in lines 247-250.

10780, 12-25: see my general comment: authors need to provide more detailed info on the aerosol model parameters used

- As mentioned above, Table 2 in the revised manuscript was edited to show detail of aerosol model parameter. Accordingly, paragraphs in lines 341-380 were revised.

10780, 26 to end of para: see comment above on surface reflectance

- As mentioned above, the uncertainty in surface reflectance was analyzed in lines 489-494 and Figure 7(d) in the revised manuscript.

10781, 10-end of para: how well does the cloud screening work? Could this be evaluated form comparison with collocated AERONET measurements?

- The performance of cloud masking was qualitative evaluated by comparing the result with GOCI RGB image. In this study, the threshold of cloud pixel was adjusted to avoid removing aerosol pixel rather than perfectly detect every cloud scene. Thus, remaining cloud can be retrieved as thick aerosol plume.

10782: section 3.2: what is the methodology used? 10793,1: how does the algorithm select an optimized aerosol type at each measured pixel? I don't think I have seen that in this MS. The flow chart in Figure 3 doesn't explain it, nor the text in Section 3. Since this is the key subject of the paper, this should be explained.

- The aerosol model was obtained by averaging each variable (refractive index, volume size distribution) with respect to season, and the AOP variation depending on AOD was considered as Levy et al. (2007).Then, an aerosol model is applied for the RTM simulation in order of season and AOD. Thus, a single LUT is adopted for a season in which the measurement was taken as described in lines 260-262.

10782, 19: what is 'radiative absorptivity'?

- The words were changed into "scattering properties" on line 321 in the revised manuscript.

10782, 23: 'regionally integrated aerosol model': what is meant with that in view of large spatial variations as shown in Figure 2? Are spatial variations not accounted for?

- Since the algorithm cannot detect aerosol type for each pixel and time, a single aerosol model was used for whole region, and that is main uncertainty in this algorithm. The limitation causes the spatial difference of comparison statistics shown in Table 3 and 4.

10783, 3: was the original data set re-analysed, or are the results from Kim et al. (2014) used for comparison?

- The original dataset was re-analyzed in this study by using same dataset shown in Kim et al. (2014)

10783, 6: 40 new sites? Table 1 lists only 35, including the original sites . . .. When the measurement period was extended by 2 years, was this for the additional sites? Which two years? How was temporal variation accounted for, i.e. were time series inspected on temporal variation over the extended period (previous period plus two new years)? Was this in some way accounted for in the application in the MI retrieval?

- Table 1 lists 69 sites. Please check right column in the table. The two years represents the extension of the period of sun-photometer measurement from the 2010. While the original group includes the dataset measured between 1999 and 2010, the new group covers the period between 1999 and 2012. The temporal variation was accounted by extending the period of inversion dataset. With the increase of period, the number of AERONET site was increased due to the DRAGON-Asia 2012 campaign. Thus, the effect of temporal extension in the integrated AOPs was analyzed in Table 2 and section 3.3.

10783, 12: AOP for 675 nm are shown, how about the wavelength dependence?

- The wavelength dependence of AOPs were analyzed and applied to the RTM simulation as described in lines 349-353, not shown in this manuscript.

10783, 22 and 24: which AOD bins?

- The description of the AOD bin was edited in lines 347-348. The range of each AOD

bin was also shown in Figure 5 and Table 2.

10783, 23: increase of SSA above 0.005? I assume that here the authors mean an increase with 0.005, which is still very small considering that a few lines above the SSA was reported with only 2 significant digits and hence this is an increase with less than 1 %! What is the uncertainty in this analysis and how significant is an increase with 0.005? Especially since only 3 months in the spring are considered here versus a long term data set? Is this a seasonal variation? An anomaly for spring 2012? Does such a minor change indeed warrant a change of aerosol model in the retrieval which already carries other important uncertainties?

- The sentence in lines 363-368 was revised to clarify the meaning in consideration with the standard deviation of the compiled SSA for spring. - The 0.005 change in SSA represents the anomaly for spring from the values of the original model shown in Table 2(a). - The paragraphs which describe the change of AOPs were edited including volume size distribution and complex refractive index in lines 362-363 and 370-377 in the revised manuscript.

10783, 24-end of para: the numbers shown here for other months than MAM, and thus using other sites than from the DRAGON campaign, are larger than the SSA increase of 0.005, and thus the extension of the number of sites and the longer period seems to have more influence than the higher density of sites, which contradicts the conclusion on 10784, 1-5. Furthermore, when the authors say 'is believed to have caused this change (10783, 29), why don't they just checked it rather than believe? 10784, 6- end of para: I don't see how this discussion contributes to 'better understanding'. Furthermore it contradicts earlier statements that particle size distributions don't change. Also, the parameters describing the volume size distributions in Fig. 5 should be provided, they are not listed in table 2 as suggested in the caption.

- To avoid the confusion, the descriptions about AOPs for other seasons were removed in the revised manuscript, and Figure 5 and Table 2 were updated. The sentences in

10784, 1-5 in the original draft were removed also.

10784, 23: a new para should be started with 'Using ..'

- The paragraph was edited on line 381 in the revised manuscript.

10785, 3: what are the assumptions in the retrieval? Is there some iteration to obtain the optimum solution? Any converging criteria used for this?

- The assumptions in this algorithm was represented and testes in section 3. The other iteration or conversion tests were not applied here.

10785, 10 and further: 4% variation in SSA corresponds to about 0.04 in absolute value, i.e. more than discussed above and more than the effect of a new aerosol model as compared to the old one.

- The reason of the 4% variation was shown in lines 402-403 in the revised manuscript.

10786, 5: negative SSA? Probably a negative error in the SSA is meant?

- The words were rephrased on line 425 in the revised manuscript.

10786, 14: 'were ranged' or 'ranged'? 10786, 21: surface reflectance at which this occurs is (insert 'at which this occurs')

- Per the reviewer's suggestion, those phrases were revised in lines 434 and 441 in the revised manuscript.

10787, Fig 7 and discussion in first para: the Figure annotations are too small to see the meaning of the colour bar and also the figures are too small. After enlarging I determined that red means an AOD of 2, and there seems to be much more red in the MI than in the MODIS images in which the AOD is about a factor of 2 lower. Hence I don't understand what is meant with 'spatially well matched', and that values are 'slightly higher'. Also, which MODIS images match up with which MI images?

- As per the reviewer's comments, Figure 8 was revised for easier viewing, and the

description was edited in lines 526-535 in the revised manuscript.

10788: section 4.2 and Figure 8: The authors claim the success of their updated aerosol model by the slope in Figure 8b which now is one, at the cost of more scattered data and lower r. However, if I compare Figures 8c and d, where, if I understand it correctly, independent data are used for the comparison, i.e. data which have not been used in the model improvement, the comparison becomes worse with the improved model: slope becomes smaller than one, and all other metrics are also decrease slightly. So in contrast to the conclusion of the authors, my conclusion would be that independent validation shows that the new model does not lead to improvement of the retrieval and hence the improvement in Figures 8a and b is due to using the same data sets for model improvement and testing. Also the Taylor diagram in Figure 9 and the data in Tables 4 and 5 do not convince me of a clear improvement: changes are visible, mostly small and are sometimes a bit better, sometime a bit worse. Were the numbers used here with the independent data or with the full data set?

- As reviewer's comments, the performance of this algorithm is spatially inconsistent due to the limitation in aerosol type selection. The problems and detail of the comparison were discussed in lines 587-593 and 632-682.

10789, 5-14: see my comments above on the accuracy in SSA and related AOD uncertainty.

- The uncertainty related with the SSA assumption was mentioned in lines 593-596 in the revised manuscript.

Section 5: several comments which have been given in the above.

- Several sentences in lines 712-713, 725-727, and 745-748 were rephrased in the revised manuscript.

Please also note the supplement to this comment:

http://www.atmos-chem-phys-discuss.net/15/C7192/2015/acpd-15-C7192-2015-supplement.pdf

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