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Atmospheric Measurement Techniques Discussions

Interactive comment on "Development of a new data-processing method for SKYNET sky radiometer observations" *by* M. Hashimoto et al.

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Author's response to Interactive comment on "Development of a new data-processing method for SKYNET sky radiometer observations" by M. Hashimoto et al.

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Dear Reviewer, We thank the reviewer for their useful comments. Below please find our answers to the reviewer's comments.

Sincerely yours, Makiko Hashimoto

——————————— Author's response ———————————

[Comment 1] p. 4363: ". . .those from AERONET, which is regarded to be the most accurate due to its rigorous calibration routines." Should be ". . .those from AERONET, which is regarded to be the most accurate due to its rigorous calibration routines and data quality and cloud screening algorithms."

[Answer 1] We revised the statement by adding "and data quality and cloud screening algorithms."

[Comment 2] p. 4363: "Therefore, we developed a new data quality control method that eliminates these error sources. . ." This is overstated. You do not eliminate these sources of error or even adequately address the surface albedo issue

[Answer 2] We agree with the reviewer's comment and revised the statement as follows, "Therefore, we developed a new data quality control method to get rid of low quality or cloud contamination data . . ." From the sensitivity test, we found that the surface albedo is one of the error sources in SSA, but countermeasures for this issue is a future task for us, so in here, abstract, we will not mention about ground surface albedo.

[Comment 3] p. 4365: It is highly unusual to place a ïňAgure (Fig 1) in the Introduction section. However my main objection to Fig 1 is the comparison of SKYNET and AERONET values at two different wavelengths. There is no point in including this ïňAgure unless the data are interpolated to a common wavelength, since quantitative comparison is pointless unless the parameters are given for a common wavelength. For AOD a 2nd order polynomial ïňAt in logarithmic space with wavelength allows for accurate inter polation to 0.5 microns (Eck et al. 1999; who also note that the AERONET measured AOT are accurate to âĹij0.01). Linear interpolation in wavelength for SSA is probably sufficient.

[Answer 3] We like to keep the figure to show temporal correlation of the AOT and SSA tendency and differences between the two network results but with interpolated values of AOT and SSA at 0.5 μm in wavelength, as the reviewer suggests, using the following equations as attached (File name is "attached_equation1.pdf", Fig. 1).

[Comment 4] p. 4365: "For the cloud screening, AERONET and SKYNET adopt Smirnov et al. (2000). . ." should be "For the cloud screening of AOT, AERONET and SKYNET adopt Smirnov et al. (2000). . ."

[Answer 4] We revised the statement as "For the cloud screening of AOT, . . ." in revise paper.

[Comment 5] p. 4365: "Each AERONET instrument is checked by means of intercalibration with reference instrument every 6 months. . ." should be "Each AERONET instrument is checked by means of intercalibration with reference instrument every 12 months. . ."

[Answer 5] Thank you very much for the correction. We corrected the description from "every 6 months" to "ever y 12 months".

[Comment 6] p. 4366: "The AERONET reference instruments are calibrated at Mauna Loa site in Hawaii, by using the normal Langley plot method and the lamp method for the determination of the calibration constants and solid view angles, respectively." Should be "The AERONET reference instruments are calibrated at Mauna Loa site in Hawaii for direct sun Vo's, by using the normal Langley plot method, and the lamp method for the determination of the calibration constants for sky radiance measurement."

[Answer 6] We added a sentence as follows: " The AERONET reference instruments are calibrated at Mauna Loa site in Hawaii for the calibration constants, V0, for direct solar irradiance measurement, by using the normal Langley plot method, and the lamp method for the determination of the instrument solid view angle for sky radiance measurement."

[Comment 7] p. 4371, last sentence: Please explain here that the error in SVA results in a sky radiance calibration error, and that this is the reason for the error of 0.03 in SSA.

[Answer 7] SKYNET SVA in the standard analysis is calculated by the point source method (Nakajima et al., 1996) by using disk scan data measured at the interval of few days (e.g.,1 week or 10 days) at certain time (e.g, 11AM in the morning), and is one month averaged data of SVA of which deviation is within 10%. However, for some sites disk scan data are missing for a long time (more than 1 year). We took standard deviation of the error of determined SVAs at Pune and Beijing, and the standard deviation is within $\sim$5%. We, therefore, put 5% error in SVA for the test. For the error $\sim$0.03 in SSA due to SVA error, it is found from the result of sensitivity test that 5% error in SVA occurs about 3% (or about $\sim$0.03) error in SSA. We added this explanation in the revise paper.

[Comment 8] p. 4377: "As discussed later, an enhanced coarse mode SDF is possibly required for several dust storm cases." You need to provide references in order to support this statement."

[Answer 8] I provided Chepil (1957), Gillette et al. (1978) and Frng et al. (2007).

[Comment 9] p. 4378: Discussion of the Cirrus case in Figure 9: In reality cirrus ice crystals typically have radius > 30 microns, (1) therefore there is an underestimation of the Optical Depth of the cirrus by as much as a factor of 2 due to forward scattering effects into the ïňĄeld of view (see Kinne et al., 1997). Did you account for this in your simulations? (2) You should also mention that cirrus is typically not spatially homogeneous and that the AERONET symmetry check (Holben et al., 2006) of the two sides of the almucanatar scan typically eliminates these cases. However the SKYNET scan only has 1 side of the almucanatar and thus cannot use that particular data symmetry quality check.

[Answer 9] (1) In simulation data, we consider the forward scattering light that measured as a direct solar irradiance in the field of view, and SKYNET retrieval algorithm has the process to remove this overestimation of direct irradiance. We also checked retrieved total optical thickness, i.e. AOD plus cirrus optical thickness of retrievals, and we can find the value is not underestimated. We added this statement in the revised manuscript. (2) The last sentence of this section "..., which is likely the case for the AERONET algorithm." made a confusion, so we like to remove this sentence from our manuscript. As for the test of cirrus contamination, the test is an ideal experiment, so we assumed that the atmosphere condition is homogeneous to check an effect of cirrus contamination, because the retrieval algorithm assumes a homogeneity atmosphere. Indeed the cirrus atmosphere is inhomogemeity, whereas we suppose it is not proper to consider atmospheric inhomogeneity in this test. However, it is important to mention about real data for such a case, so we added a statement to describe the scanning difference between AERONET and SKYNET, and about inhomogeneity in cirrus contamination in section 3, "3.1 Case study".

[Comment 10] p. 4379: "In the period of cirrus contamination, AERONET consistently rejected data through their cloud screening (Smirnov et al., 2000)." This is NOT true for Oct 23, 2008 at Pune, since the AOT did pass the Smirnov cloud screening (only applied to AOT data), but the retrievals did not reach level 2 due to large error between the measured and computed sky radiances and the almucantar asymmetry check (see Holben et al., 2006).

[Answer 10] Thank you very much for e the correction. we corrected the sentence as follows: "In the period of cirrus contamination, AERONET consistently eliminates the data through their symmetry check of the two sides of the almucantar scan (Holben et al., 2006), whereas the SKYNET scan only has one side of the almucantar and thus cannot use such symmetry quality check."

[Comment 11] p. 4379: In reference to the Beijing case of April 14, 2004 (Fig 12& 13): The Angstrom exponent of 0.49 indicates a ïňĄne/coarse mode mixture (see Eck et al., 2010), NOT necessarily very large coarse mode particles. In situ data are needed to support your case for the presence of very large coarse mode dust as suggested by the SKYNET retrieval. You also need to mention if the surface reïňĆectance inputs to both the SKYNET and AERONET retrievals were the same for this comparison, since

in practice they typically are not the same and that difference alone can account for some difference in retrieved SSA and size distribution.

[Answer 11] Figure 12, a lidar result, indicates that there are high dense aerosols into 3km height from backscattering intensity, non-spherical particles, i.e. dust particle, from depolarization ratio, and large particle from color ratio of scattering intensity. However, we will provide a reference, Wu et al. (2009), which indicates the result of in-situ measurement in dust events from 2004 to 2006 and we confirmed coarse mode dust in the period of figures 12 and 13. For angstrom exponent, Eck et al. (2010) mentions about the cases that Angstrom exponent indicates a ïňĄne/coarse mode mixture, especially the value is > 1.1. In this case, the value is $\sim$0.49 and there is a possibility that there are large particles from the lidar result and Wu et al. (2009). We plotted the volume size distribution by log-log plot as attached (File name is "attached_figure1.pdf", Fig. 2). This figure shows the SDFs from the two networks both show a small fine mode indicating the fact that fine and coarse mode aerosols were coexisting in the atmosphere as also shown by the lidar observation. We removed the fine mode and calculated Ångström exponent using retrieval values. Then we got very small Ångström exponent, -0.1. For the values of ground albedo, used values in SKYNET and AERONET are different, and it is one of the error causes in SSA, so we revised the sentence about the comparison of SSA and SDF as follows:

[Before] "Additionally, the Angstrom exponent from SKYNET was consistently as small as 0.49, indicating the existence of large particles. We compared the SSA value and SDF retrieved by SKYRAD.pack version 4 with AERONET values in Fig. 13. As shown in the figure, a large amount of coarse particles with radius around 10 μm exist in the SKYNET results, whereas the SDF from AERONET does not include particles larger than 10 μm. The SSA values from AERONET are lower than those from SKYNET, consistent with the result of numerical experiments in the previous section. In the case of dust, that is, version 4 works better than version 5. Since cirrus cloud was not detected from the lidar, it is likely that the difference in the two products was caused by the difference in the inversion algorithms. More studies in the future, including validation of the SDF, will be needed to deduce the reasons for this difference, because there are several differences between the AERONET algorithm and version 5 of SKYRAD.pack. ”

[After] “Additionally, the Ångströme exponent from SKYNET was consistently as small as 0.49, indicating the existence of large particles, and coarse mode particles were detected by in-situ measurement (Wu et al., 2009). We compared the SSA value and SDF retrieved by SKYRAD.pack version 4 with AERONET Level 2 data in Fig. 13. As shown in the figure, coarse particles with radius around 10 μm exist in the SKYNET results, whereas the SDF from AERONET does not include particles larger than 10 μm. The SSA values from AERONET are lower than those from SKYNET, consistent with the result of numerical experiments in the previous section. Since cirrus cloud was not detected from the lidar, it is likely that the difference in the two products was caused by the difference in the inversion method. However, we cannot conclude this point, because there are several differences between the AERONET algorithm and SKYRAD.pack, e.g. input parameters such as surface albedo, instrument calibration method and scanning system. Therefore, more studies, including validation of the SDF, will be needed in the future.”

[Comment 12] p. 4380: Note that Yoram Kaufman stated that the cloud screening of Kaufman et al, 2006 does not work for cases where coarse mode dust dominates the size distribution.

[Answer 12] We provide the reference to indicate that Kaufman et al. (2006) are used as the present cloudscreening algorithm in the SKYNET standard analysis.

[Comment 13] p. 4382: You should note here in the text that determining the empirical values of the Cv threshold requires a large database, and that this complicates it’s implementation.

[Answer 13] Yes, we require a large database, in particular at sites that include both

a large dust case and cirrus contamination case for this threshold. In this paper, we checked data at the Pune and Beijing sites that include large dust cases for one year, comparing cirrus-detected data from MODIS lidar or NIES lidar with no cirrus-detected data, and Cv=2 was suitable to separate the cirrus-detected and no cirrus-detected data. Indeed we need to develop this method with larger database, but the idea is useable for SKYNET version 4.2 retrieval data analysis. Development of this method will be an immediate future work. However, the sentences about this content have a possibility to cause a confusion, so that we improved the sentences as follows:

[Before] “The values of Cv is an empirical value from the data at the Pune site, and the aerosol condition varies depending on the site. Therefore, we should consider the condition of observation sites for this value and use different values for each observation site”

[After] “The value of Cv is determined from one year data of the Pune and Beijing sites. It will be necessary for future work to determine this value after we collect more dust day data and cirrus contamination data.”

[Comment 14] p. 4383: “The differences in the spring SSA at Pune in May and Beijing in April were 0.073 and 0.008, respectively, and the differences in the autumn SSA at Pune in October and Beijing in September were 0.017 and 0.043, respectively.” Please state in the text whether the AERONET data were for fully cloud-screened data and whether these were Level 2 AERONET retrievals. [Answer 14] We added a description: “We used Level 2 AERONET retrievals with that cloud screening.”

[Comment 15] p. 4385: “For such dust cases, the SSA can be underestimated by AERONET because of their constraint on the presence of very large particles in the SDF, which do not have a large volume for radius values greater than 10 μm.” This is NOT proven in this paper and therefore should not be included in the Conclusions section. Just because SKYNET retrieves larger coarse mode particles and higher SSA does not mean that the AERONET retrieval of SSA is an underestimate. Other recent studies have shown good agreement between AERONET retrievals and in situ measurements for both SSA and PSD (see Toledano et al. 2011, and Johnson and Osborne, 2011).

[Answer 15] The reviewer is right. There are many other differences to cause the SSA difference, so we revised the conclusion as follows:

[Before] "For such dust case, the SSA can be underestimated by AERONET because of their constraint on the presence of very large particles in the SDF, which do not have a large volume for radius values greater than 10 μm."

[After] "It is found that the version 5 of SKYRAD.pack with posing a constraint of suppressed coarse mode particles of radius larger than 10μm causes the overestimation of SSA in the dust case with significant concentration of over 10 μm particles. We need more studies to conclude this different is the cause of the SSA difference between AERONET and SKYNET in the case of dust case, because there are many other differences between two networks."

[Comment 16] p. 4385: "There are past reports (e.g. Mikami et al., 2006; Formenti et al., 2011) that show measured SDFs of soil particles with an extended tail for sizes larger than 10 μm." However other papers suggest that the SDF's of airborne dust does not have a tail beyond 10 micron radius (see Reid et al. 2003 (African dust), Reid et al. 2008 (Middle East dust) and Johnson and Osborne 2011 (African dust)). Therefore it seems that you are overstating your case here for the presence of these large dust particles, which will tend to be removed quickly from the atmosphere by gravitational settling.

[Answer 16] We confirmed the reference papers that the reviewer provide regarding no tail beyond 10 μm. However, it is also a fact that there are cases of the volume size distribution of soil particles with an extended tail for sizes larger than 10 μm (Zhang at al., 1998; Feng et al., 2007). These large 10 μm tail cases are minor cases, but we think that it is important to consider such possibility. We revised the manuscript to

include this discussion:

[Before] "There are past reports (e.g. Mikami et al., 2006; Formenti et al., 2011) that show measured SDFs of soil particles with an extended tail for sizes larger than 10 μm. However, it should be pointed out that observation of . . ."

[After] "There are past reports (e.g. Mikami et al., 2006; Formenti et al., 2011; Zhang at al., 1998; and Feng et al., 2007) that show measured SDFs of soil particles with an extended tail for sizes larger than 10 μm, though these cases are not quite so common in dust cases (e.g. Reid et al. 2003; Reid et al. 2008; and Johnson and Osborne 2011). We need to accumulate a priori SDF information for dust cases."

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 4361, 2012.

$$\ln\tau_{0.5\mu m} = \frac{\left(\ln\tau_{0.675\mu m} - \ln\tau_{0.44\mu m}\right)\left(\ln\lambda_{0.5\mu m} - \ln\lambda_{0.44\mu m}\right)}{\left(\ln\lambda_{0.675\mu m} - \ln\lambda_{0.44\mu m}\right)} + \ln\tau_{0.44\mu m}$$

$$\tau_{0.5\mu m} = \exp\left(\ln\tau_{0.5\mu m}\right)$$

$$\tau_{scattering} = \omega \cdot \tau_{extinction}$$

$$\tau_{s0.5\mu m} = \exp\left[\frac{\left(\ln\tau_{s0.675\mu m} - \ln\tau_{s0.44\mu m}\right)\left(\ln\lambda_{0.5\mu m} - \ln\lambda_{0.44\mu m}\right)}{\left(\ln\lambda_{0.675\mu m} - \ln\lambda_{0.44\mu m}\right)} + \ln\tau_{s0.44\mu m}\right]$$

$$\omega_{0.5\mu m} = \frac{\tau_{s0.5\mu m}}{\tau_{0.5\mu m}}$$

Fig. 1. Equation for interpolation of SSA and AOT at wavelength 0.5μm using wavelengths 0.675 and 0.44μm.

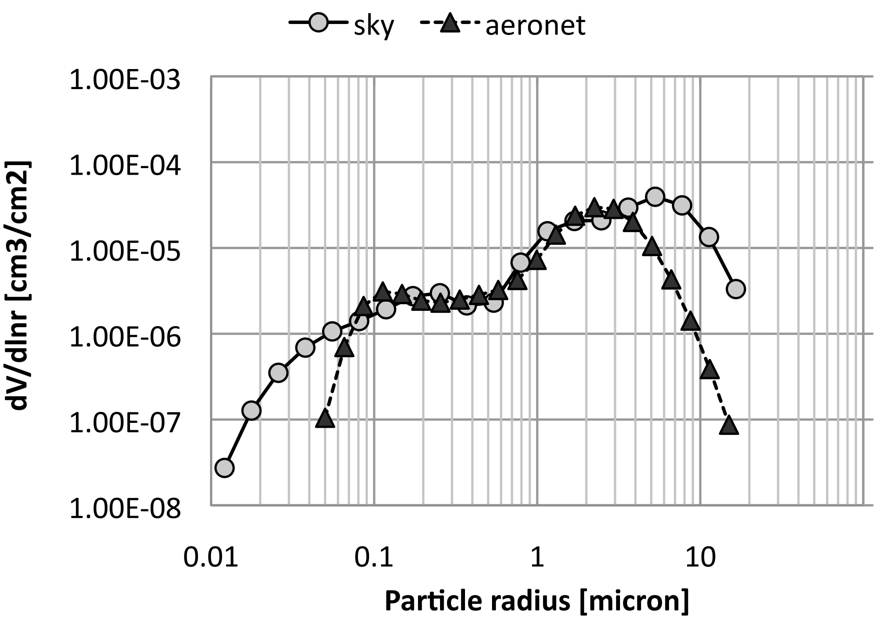

Fig. 2. Volume size distribution by log-log plot of SKYNET (sky) and AERONET (aeronet) on 14 April 2004 9:00:00 UTC at Beijing.