# Response to comments of Reviewer 2

Authors would like to express sincere thanks to an anonymous reviewer for his/her valuable comments. We revised a manuscript very carefully based on given comments. The comments of the reviewer are in blue, our replies are in black, and changes made in the revised manuscript are in red. Our replies to the comments are as below.

The development of the algorithm in this study is important because it is of great merit for radiometers to make their self-calibrations on-site. However, there are some issues to be clarified before publication finally, in terms of the detailed points below. In addition, it is recommended to have the manuscript English-proofed.

➔ Thank you for your encouraging comment. The manuscript has been read by a professional native English speaker.

Specific comments:

L67-68 "We use three carefully selected wavelengths to retrieve COD and CER simultaneously." How did the authors carefully select the wavelengths?

➔ They are described in the revised manuscript as below.

We use sky radiances ($E$) observed at three longer wavelengths (0.87, 1.02, and 1.627 μm), excluding 2.2 μm, which is not used for two main reasons. First, our statistical analysis suggests that the number of unphysical data (observation data recorded as 0) for 2.2 μm is high; thus, 2.2 μm is excluded to increase the retrieval number. Second, the longest wavelength used by AERONET is 1.64 μm; so the proposed algorithm could be easily used for sun photometer observed data as well. Wavelengths shorter than 0.87 μm are not used to avoid the effect of aerosols as far as possible.

L95 Fig. 1 Do the authors specify some criterion for the number of iteration? Do all the observed data properly retrieved?

➔ The total number of iterations is set as 50. If the solution does not converge within 50 iterations, the analysis is discarded.

L181 Fig.4 From Fig.4, it seems that transmittances of the three wavelengths have dual values for a certain effective radius of cloud droplet. For example, the values 0.7 of transmittance

appear at two regions of cloud optical depth more than and less than 10. The situation might cause the problem of dependency on a-priori or a starting value of the iteration in Fig. 1 and x_a in Eq. 2. Does the issue is not critical for this study?

➔The *a-priori* values are climatological data sets, and they are fixed in the algorithm. The starting values of COD and CER can have an important effect in the retrieval as suggested by the reviewer. Our approach to overcome this problem is described in the revised manuscript as below.

As highlighted in Sections 1 and 4, transmittance signals may not always be characterized by unique COD or CER values. Consequently, the initial values of COD and CER used for iteration can be important when searching the plausible set of COD and CER values. To address this important issue, we first approximate the initial COD and CER values to start the iteration. The approximation is done by searching a set of COD and CER values by comparing observed $T_{1.627}/T_{1.02}$ and $T_{1.02}$ with LUT of corresponding values modeled for COD values of 1–64 and CER values of 2–32 µm in steps of 1 µm. $T_{1.627}/T_{1.02}$ generally decreases with the increase of COD; whereas when COD increases, $T_{1.02}$ increases first until reaching the peak value, and then starts to decrease. Thus, $T_{1.627}/T_{1.02}$ and $T_{1.02}$ can be used simultaneously to determine the range of COD and CER in which the true values are likely to fall. A set of COD and CER values that generate the smallest root mean square difference between the observed and modeled values is used for the initial values in the iteration.

L199 "Note that the absorption tends to reduce T( ), whereas the forward scattering tends to increase it." In terms of cloud retrieval, multiple scattering is important for larger COD, which will enhance the forward scattering and absorption processes.

➔We refined the sentences as suggested by the reviewer as

Both the forward scattering and absorption can increase with the increase of COD along with the increase in multiple scattering; the increase in $T(\lambda)$ before the peak value is due to the dominance of forward scattering over absorption, and vice versa for the decrease in $T(\lambda)$ after the peak value.

L223-224 "a narrow-angle (NA) radiometer (FOV: 5)" The observation was conducted in the zenith direction same as the sky radiometer?

➔ We provided information below to clarify this issue.

The instrument was calibrated by the manufacturer in the laboratory, and the observed signals are converted into radiance (unit: $W/m^2/sr$) by using the company provided calibration constant

value. Because the narrow-angle radiometer faces upward, thus obtained radiance is from the zenith.

Fig. 6 The slope of the solid line should be multiplied by 2*phi. Currently, the pyranometer observation seems overestimated greatly, compared with narrow angle radiometer, which might mislead to inconsistency of the two observations.

➔As suggested by the reviewer, the slope of the solid line is multiplied by 2*phi.

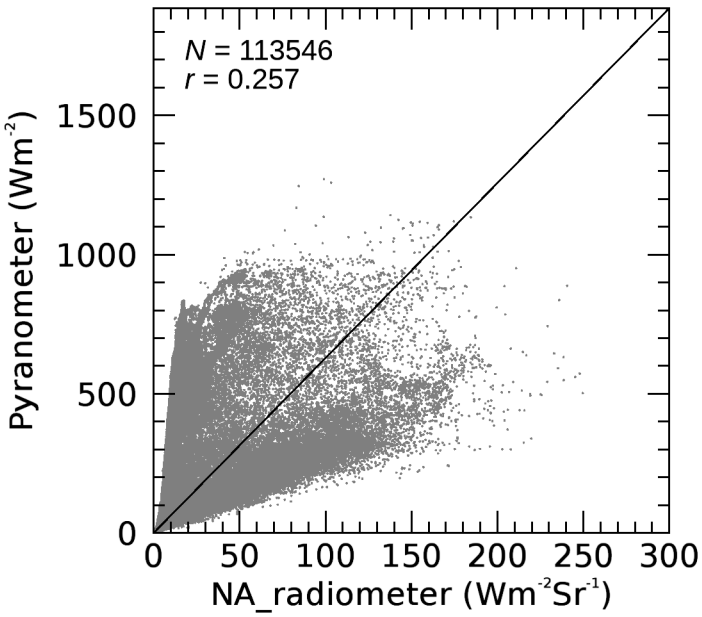


Figure 6: Scatterplot of broad-band radiances and irradiances observed with a narrow-angle radiometer and a wide-angle pyranometer at Chiba (35.62°N, 140.10°E) during January–March 2016. The solid line represents $y = 2\pi x$.

The solid line hardly suggests the overestimation from pyranometer as data points are scattered in both sides of a solid line. On the other hand, it indicates the asymmetric distribution of radiance.

Technical corrections:

L28 "Foster" -> "Forster"

➔ It is corrected in the revised manuscript.

L59 "MCBride" -> "McBride"

➔ It is corrected in the revised manuscript.

L120 "(r)" rather than "(r^2)"

➔ It is done in the revised manuscript.

L163 "priory" -> "a priori"

➔ It is corrected in the revised manuscript.

L169 Fig. 3b, 3e, 3h, and 3k The style of right axis should be same as the other panels.

➔ They are done in the revised manuscript.

L236 "qualitative" -> "quantitative" ?!

➔ It is qualitative.

L270 "Figures 6(a) and 6(b)" -> "Figures 7a and 7b"

➔They are corrected in the revised manuscript.

Figure 7, Legends: Please omit the dual markers for each site.

➔They are done in the revised manuscript.

L276 "Figs. 7(a) and 7(b)" -> "Figs. 8a and 8b"

➔They are corrected in the revised manuscript.