Replies to comments of Reviewer 1

Authors would like to express sincere thanks to an anonymous reviewer for his/her valuable comments and suggestions. We carefully revised the manuscript following the given suggestions and comments. Our replies to the comments and suggestions are given below.

It is important to assess SGLI-observed cloud properties using surface data, such as SKYNET data. The authors discuss the quality of the two most fundamental cloud properties—COD and CER of both water and ice clouds From SGLI. In fact, it is not easy to do this kind of assessment. In particular, the author should pay attention to the following issuesï¼š

--> Thank you very much for giving us positive feedbacks.

1. Objects ï¼ˆcloudsï¼‰ seen from satellites and the ground need to be substantially identical.

--> We agree with the reviewer. We made enough efforts to address this important issue in our study. First of all, we performed parallax-correction to all space-based SGLI cloud products before comparing them with surface-based sky radiometer results (**Page 4, Lines 136-141**). Though cloud systems move, however, in a statistical context, temporally averaging the surface measurements can be regarded to be equivalent to spatially averaging them over the satellite grid (Cess et al., 1995, 1996). Therefore, space-observed cloud properties are being evaluated using surface-observed values by taking spatial and temporal averages of space- and surface-observations, respectively (e.g., Dong et al., 2008; Nakajima et al., 2005; Takamura et al., 2009; Yan et al., 2015). This study follows similar procedure practiced over last few decades **(Pages 4-5, Lines 141-148)**.

2. The algorithm that distinguishes between ice and water clouds requires precision and rigor to achieve good results.

--> We agree with the reviewer. As the focus of this study is to evaluate two most fundamental cloud properties—cloud optical depth (COD) and cloud-particle effective radius (CER)— of SGLI, for the purpose of this study, we retrieved cloud properties from sky radiometer by using scattering database for water (ice) cloud, if cloud detected by SGLI is water (ice). In other words, cloud phases for sky radiometer data analyses are consistent with SGLI observations to better evaluate the qualities of SGLI cloud products (COD and CER) available for public use. Since retrieval algorithms for SGLI are being upgraded periodically, cloud phase detection algorithm may be upgraded in the future, and consequently cloud products may be upgraded as well.

3. As the authors say, the SGLI-observed CER exhibits poorer agreement than does the COD, with the SGLI values being generally higher than the sky radiometer values. And what's the reason? and how to improve? should be discussed in deatail.

--> As suggested by the reviewer, we discussed in detail regarding poor agreement of CER between sky radiometer and SGLI. We further discussed about future prospects of research for the improvement of CER retrievals and quality assessment studies. They are described as below in the revised manuscript (**Page 6, Line 222 - Page 8, Line 256)** .

There can be a number of reasons for such poorer agreement for CER. First, unlike surface-based sky radiometer, the upper portions of clouds are sampled more readily than lower parts in space-based SGLI. Since cloud-droplets can have vertical inhomogeneity with upper cloud portions containing both relatively large-sized (e.g., an adiabatic growth at the beginning of cloud generation) as well as small-sized (e.g., entrainment of dry air at the cloud top, collision-coalescence process) particles, CERs retrieved from SGLI observations can become both larger and smaller than those retrieved from sky radiometer observations, as noted in Figure 2, depending on vertical inhomogeneity of clouds. Further, as the absorbing wavelengths, which are critical for CER retrievals, corresponding to current SGLI and sky radiometer cloud retrieval algorithms are 2.2 and 1.6 μm, respectively, these different wavelengths can have different absorptions to further enhance the difference in CER between SGLI and sky radiometer. Except them, quality of data samples used for the comparison holds an important position to determine the comparison metrics, such as r value, RMSE, and MBE. For example, if we screen data shown in Figures 1 and 2 by selecting only those that have coefficient of variation (COV), i.e., the ratio of standard deviation to the mean, less than 0.2, the comparison metrics, including those for CER comparisons, can have different values (Figure 3 in the revised manuscript, but Figure R1 in this response sheet). Figure R1(a) shows a very good agreement for CER comparison for water clouds. On the other hand, the comparison metrics corresponding to CER comparison for ice clouds are still poor because a limited number of *samples show considerably large difference between sky radiometer and SGLI. However, on the other side, it is still encouraging to see a considerable number of samples falling around 1:1 line in Figure R1(b). Nevertheless, Figure R1 suggests an important role of data handling procedure while evaluating cloud properties obtained from space-based observations with those from surface-based observations. Further, as the number of scattering within cloud layers increases with the increase of cloud thickness, COD can be suggested to play an important role in retrieved CER value. The influence of COD on retrieved CER in satellite remote sensing has been discussed in detail from both theoretical (e.g., Nakajima and King, 1990) as well as observation perspectives (e.g., Zhang and Platnick, 2011). Similarly, Khatri et al. (2019) showed the influence of COD on retrieved CER for surface-based sky radiometer. Figure 4 (Figure R2 in this response sheet) shows the relationship between CER difference, i.e., ΔCER (CER_{SGLI}-CER_{skyrad}) and COD_{SGLI} for water clouds and ice clouds. In general, Figure R2 suggests a negative correlation between ΔCER and COD_{SGLI}. Such negative correlation is relatively less prominent for ice clouds than for water clouds, which can probably due to irregular shapes of ice cloud particles that adds complexity while retrieving cloud properties in both sky radiometer and SGLI observations. Figure R2(a) suggests that SGLI and sky radiometer CERs, in general, may have relatively close agreement for CODs around 20. Note that CODs from SGLI and sky radiometer also show relatively close agreement for CODs around 20, as discussed above. Figure R2(a) further suggests that CER values from SGLI can be higher (lower) than sky radiometer values when clouds are relatively thin (thick). This result again coincides with relatively higher values of COD from SGLI than those from sky radiometer for relatively thin (thick) clouds. On the other hand, Figure R2(b) suggests that relatively very large difference in CER between SGLI and sky radiometer can generally occur for relatively thin clouds. Note that retrieved CERs can have larger uncertainties for optically thinner clouds in both surface and satellite retrievals (Khatri et al., 2019; Nakajima and King, 1990). Nevertheless, Figure R2 suggests that CER difference between SGLI and sky radiometer can vary differently depending on COD value, suggesting COD as one important candidate for CER difference between them. Along with these factors, differences in ancillary and surface reflectance data in the retrieval algorithms of SGLI and sky radiometer may also contribute partially to bring differences in retrieved values of CER as well as COD between SGLI and sky radiometer. Although such manifold factors can be responsible for differences in CER values between SGLI and sky radiometer, most of the data samples show higher CER values from SGLI than from the sky radiometer, resulting in negative values of MBE for both water and ice clouds. This result is in line with previous studies that* *showed higher values from satellite observations compared with values obtained from surface and/or aircraft observations (e.g., Painemal and Zuidema, 2011; Chiu et al., 2012; King et al., 2013).*

The comparison results discussed above suggest some future research scopes. Since cloud-droplet vertical inhomogeneity can have important effects on retrieved cloud properties for both space- and surface-observation data, future studies may effectively implement observation data of active sensors, such as surface-observation based lidar, as well to improve and strengthen the quality assessment of CER values obtained from SGLI and other similar satellite sensors. Furthermore, CER retrievals from SGLI (sky radiometer) may be extended for absorbing wavelength of 1.6 μm (2.2 μm) for further improving and strengthening such quality assessment studies as well as expanding our understanding regarding CER property. In addition, along with sky radiometer, other surface-based radiometers, such as rotating shadow-band spectro-radiometer (Khatri et al., 2012; Takamura and Khatri, 2021), that have wide field of view (FOV) can be brought in use for remote sensing of cloud properties from surface and to validate space-observed cloud properties more rigorously.

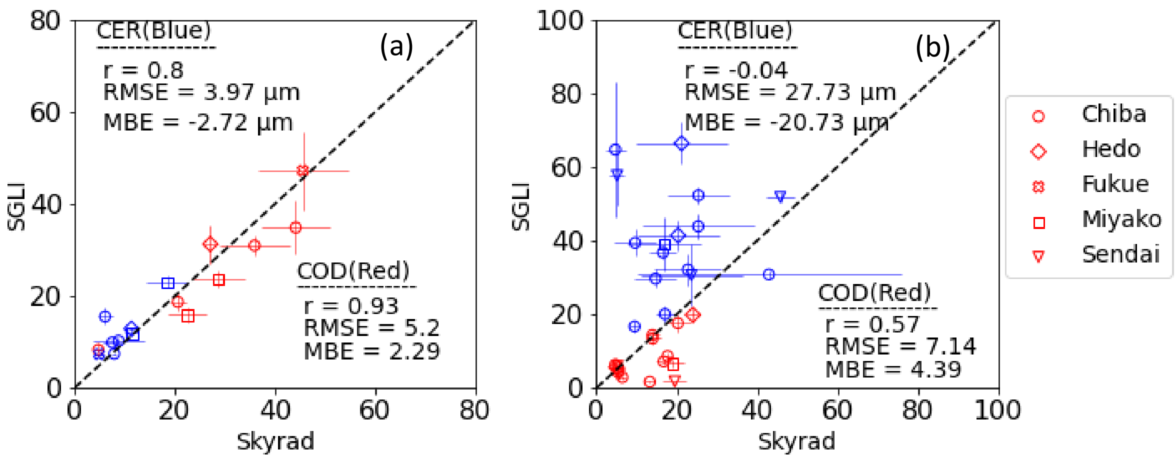

Figure R1. Comparison of cloud properties (COD and CER) between sky radiometer and SGLI for (a) water clouds and (b) ice clouds by selecting data samples with coefficient of variation (COV) less than 0.2.

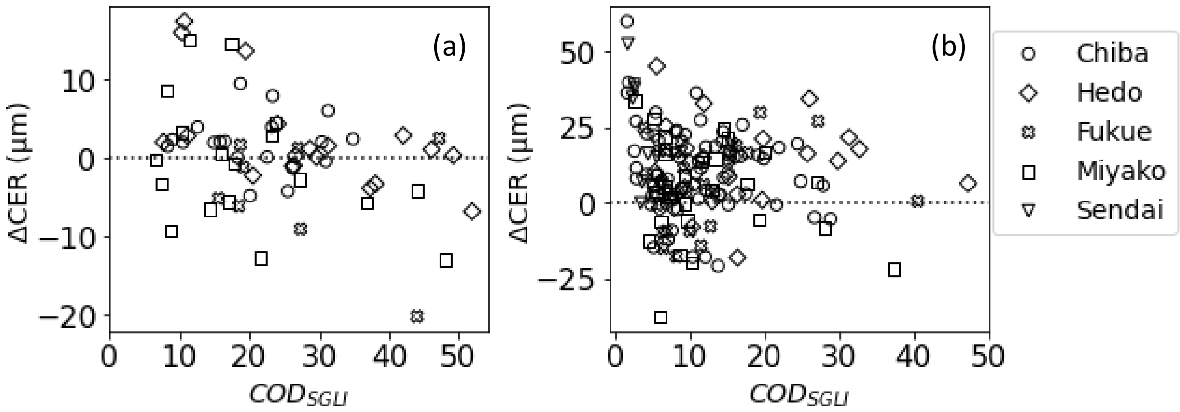

Figure R2. Comparison between ΔCER (CER_{SGLI}-CER_{skyrad}) and $SGLI_{COD}$ for (a) water clouds and (b) ice clouds.

4. some errors such as: ... "and (iii) the SGLI COD can be underestimated (resp. underestimated) for optically thick (resp. thin) clouds. in line 386;" ..."for ice clouds and the tendency to underestimate (resp. overestimate) the COD in SGLI observations for optically thick (resp. thin) clouds." in line 35;

--> Thank you very much for pointing out typo. As suggested by the reviewer, there are inconsistent statements in the abstract and conclusion sections. The typo of conclusion is corrected in the revised manuscript (**Page 13, Line 447**).

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