Response to comments of reviewer 2

General comment	*Response*
This paper is one of the most comprehensive overviews of techniques (including the one by the authors) that employ zenith-viewing shortwave spectral radiance observations, and the authors can be commended on this, as well as on the thorough validation of their new effective radius and liquid water path retrieval, which is an extension of the retrieval of optical thickness, based on the AERONET cloud mode, presented in an earlier paper (2010). Not only do the authors compare their retrievals with various other observations (MWR, MODIS,...), they also study the impact of 3D effects on the retrieval accuracy.	• Thank you.

Response to comments of reviewer 2 (cont.)

Minor revision/addition	*Response*
1. One of the issues that has been plaguing these kinds of retrievals are the effective radius uncertainties, due to the compensating effects of enhanced forward scattering on the one hand and enhanced absorption on the other, for increasing particle size. Each publication so far has had to describe how the issue was overcome in each particular case. Here, very reasonable assumptions are made about the observational errors, and their propagation into the retrievals. Somewhat surprisingly though, the effective radius uncertainties (and thus, the uncertainties in liquid water path as well) are small. Can the authors provide an explanation as to why their retrieval produces smaller errors than, say, a retrieval combining only two wavelengths (e.g., 870 nm and 1640 nm)? Most likely, the improvement over dual-channel techniques comes from the addition of the 440, 675, and 1020 nm channels, but it would be nice to have this quantified (and explained). For example, a comparison of the magnitude of uncertainties could be made when using the full set of wavelengths vs. only two.	• Thank you for bringing up this interesting point. This question could be interpreted from many angles; hopefully, we cover all of them here. • Firstly, the reviewer seems to be surprised by the retrieval uncertainty in effective radius, because it is smaller than the input uncertainty. The input uncertainty of 17% mentioned on Page 19169 was an estimate from the sum in quadrature of the input relative uncertainties. Since the retrieved parameters are not in a simple product and quotient form of these input parameters, the 17% input uncertainty is used as a reference. We also double-checked results for the case when 1000 repetitions were used. The resulting retrieval uncertainty in effective radius remains ~12%, indicating that this estimate is robust. • Secondly, the reviewer seems to be surprised by the retrieval uncertainty, because it is smaller than the uncertainties reported in literature. For real observations, our retrieval uncertainty (~20%) is actually comparable to others. • Thirdly, to investigate the benefit of the additional channel, we tested a method that used zenith radiances at 870 nm and 1640 nm wavelengths. Results show the removal of 440 nm has negligible impact on cloud optical depth (differences in bias and RMSD are 0.4 and 5%, respectively). For $r_{eff,constLWC}$, the bias and RMSD change from –0.8 to –1.6 µm, and from 1.7 to 2.4 µm, respectively. For $\bar{r}_{eff,}$ the bias and RMSD change from –0.1 to –0.8 µm, and from 1.4 to 1.7 µm, respectively. Note that in reality, calibration for 1640 nm is harder than that for 440 and 870 nm; therefore, the inclusion of 440 nm in the retrieval method can help ensure retrieval quality.

Response to comments of reviewer 2 (cont.)

Minor revision/addition	*Response*
	• Finally, we didn't use 675 and 1020 nm because of the following reasons. 1) Since the surface albedo contrast between 675 and 870 nm is smaller than that between 440 and 870 nm, the use of 675 nm is not as good as that of 440 nm. 2) In reality, the use of 1020 nm will be a bit challenging and could be more uncertain, because surface albedo estimate at this wavelength is not available from MODIS products. • Note that our retrieval method included input uncertainty randomly by repeating the retrieval process; this procedure takes time to run, but the mean is more representative than a single retrieved value that could be more sensitive to input uncertainties.
2. Also, the McBride et al. (2011) paper (Figure 10 and text) demonstrates that the uncertainties in reff depend on the cloud optical thickness (there are certain ranges that are more favorable to a reff retrieval than others). How is it here? Would it be possible to add a plot that shows the Reff and/or LWP retrieval uncertainties as function of optical thickness?	• Thank you for this interesting point. Suppose that the reviewer refers to *McBride et al*. (2011) in ACP. Results in Figure 10 were based on comparisons between two different retrieval methods, and thus it is hard to define retrieval uncertainty when we don't know the truth. • Unlike Table 1 and discussions in Sect. 3.2 in *McBride et al.* (2011; ACP), errors in our retrieved effective radius and LWP for the I3RC case do not show clear dependences on cloud optical depth. To better address reviewer's question and make sure we are comparing the same things, we conducted sensitivity tests, similar to Table 1 in *McBride et al*. (2011), using a given effective radius of 10 µm, various cloud optical depths and a solar zenith angle of 45°. As shown in the new Table 2 in the manuscript (duplicated below), the error in our retrieved effective radii does not have a clear dependence on cloud optical depth.

True cloud optical depth (COD)	Retrieved COD	Relative error in COD (%)	True effective radius r_{eff} (µm)	Retrieved r_{eff} (µm)	Relative error in r_{eff} (%)
10	9.8 ± 2.4	–2	10	10.5 ± 2.3	5
20	21.4 ± 1.3	7	10	9.8± 2.4	2
40	42.0 ± 1.6	5	10	10.3 ± 1.8	3

Response to comments of reviewer 2 (cont.)

Minor revision/addition	*Response*
3. It should be added that it is entirely possible that 3D effects (nicely included in this paper) outweigh the radiometric uncertainties; it would be nice to see the relative contribution of both these effects (radiometric uncertainties and 3D effects) quantified somewhere, but this is perhaps beyond the scope of the paper.	• Investigations of 3D effects on retrieved cloud optical depth and effective radius are ongoing research. Since these effects will be discussed in a different structure from the current paper (e.g., considering various solar zenith angles, solar azimuth angles, cloud types, etc.), we agree with the reviewer that it has a different emphasis and is beyond the scope of the paper.

Minor comment	*Response*
4. The choice of "source" in figure 1 is unfortunate; how about "reference"?	• Thank you for your suggestion. We have revised x-label and the figure caption. To be more specific, the word "source" has been replaced with "cloud radar or MODIS". The figure caption now starts with the following sentence: *Scatter plot of effective droplet radii retrieved from ground-based transmittances versus those from either ground-based cloud radar (dot) or MODIS (triangle) observations.*
5. Figure 5: This is where the discrepancy between "true" and "retrieved" could be shown as a function of optical thickness.	• New sensitivity tests and a new table have been added as the second paragraph in Sect. 2.2: *The plane-parallel cloud cases have a fixed effective radius of 10 µm with various cloud optical depths, similar to set up in McBride et al. (2011). The input zenith radiances were calculated from DISORT. Table 2 shows that the relative difference between true and retrieved cloud optical depths is around 2–7%, while the difference in effective radius is around 2–5%. These errors for the ideal 1D clouds are used as a benchmark to understand how much the retrieval error will increase in a realistic 3D cloud, as shown next.* • Please see Comment #2 for details.
6. p19181, L13: typo: add space before "r_retrieve"	• Thank you. This has been corrected.
7. p19182, L1: Replace "Thank" with "Thanks".	• We believe that "Thank" here is correct.