The authors build on prior studies to develop a 3-D effective radius profile retrieval, designed for deployment to field measurements of cloud sides in a follow-up study. The proposed retrieval is comprised of a Bayesian approach and includes means to mitigate the impacts of unknown cloud surface and vertical structure.

The paper is mostly well written and the presented analysis is thorough. In my opinion some of the methods to mitigate 3-D radiative effects and the reasoning for their employment are not sufficiently described and justified, and some minor structural and language issues impair the readability of the work. My recommendation is to accept the manuscript after minor revisions. I include a list of general and specific comments/recommendations that should help the authors in improving upon this first submission.

General Comments:

1) The authors included a paragraph in the introduction, which addressed my initial concerns about the manuscript (i.e., novelty). This is well done. However, I feel it would help to summarize the advances in regard to older, similar studies, again in the conclusion. Here, the authors mention that the study advances on prior frameworks, but specifically highlighting the limitations of these older studies and the advances would highlight the impact of the submitted work. One or two sentences should suffice.
2) The paper mentions that the retrieval is designed to drive the retrieval of cloud properties for observations performed with their own specMacs instrument. The authors point out several times that the retrieval conditions are designed to mimic the conditions encountered during these campaigns. Unfortunately, the sampled measurement, field campaign/campaigns and the encountered conditions are never explicitly mentioned anywhere in the paper. From what I can gather from the tables and figures, the observed clouds during the specMacs employment were small cumuli , low flight altitudes of < 2km, cloud top heights between 1.5 and 2km, CCN concentrations up to 1000 cm-3, possible solar zenith angles up to 67deg, the airplane about 2-3 km away from the clouds. Is this correct? From my quick research the measurements were performed with the European HALO aircraft; did you really fly in an altitude of < 2km? I feel it would help to at least mention the campaigns and the overall conditions encountered during the measurement flights.
3) I would recommend to thoroughly proofread the manuscript, if possible by a native English speaker. Some sentences are awkward, there are a number of extra words and punctuation marks that can be removed, some citations are not implemented correctly, and I feel some sentences can either be split up or readability can be improved by commas.
4) Maybe I am missing something, but it is not sufficiently explained and justified, why the gradient classifier g is preferable to the deviation delta_L_2.1. They look similar, but there are obvious differences. Why would g be better than L?

5) The derived moments from the LES droplet size spectra are used to derive the "truth" for the retrieval comparison. Not only would I recommend to avoid scientifically wrong designations like "truth" here, the process of deriving the LES variables for r_eff and LWP is not straightforward and induces more uncertainty; see Alexandrov et al., 2012b; Miller et al., 2016; Zhang et al., 2017, Miller et al., 2018. A lot more information is needed here. How did you average each profile within each height, how did you incorporate weighting functions, etc.
6) It is mentioned several times that the proposed retrieval seems reasonable for optically thick clouds. However, it is never mentioned what this actually means, and whether these conditions are realistic for the expected clouds. At one point, the authors assume tau=500, which from a TOA perspective seems exceptionally high. Is this the regime where we can assume the retrieval to produce reasonable results?

Specific Comments:

- Page 1, line 6: remove "with"
- Page 1, line 6: do you mean "small scale cloud heterogeneity"? What do you mean by "small scale structure"?
- Page 1, line 18: Remove the subheading. There is no other subsection in the introduction…
- Page 2, line 35: This sentence is hard to read and a bit awkward. Maybe change to " .., where the observer position is located within the cloud field."
- Page 3, line 6: fix citation
- Page 3, line 7: Which data set do you mean here? This is not about the specMacs measurements, correct? This is the statistical retrieval data set for the Bayesian reff retrieval, correct? Please clarify.
- Page 3, line 12: pixels (plural)
- Page 3, line 15: awkward sentences, maybe add " … and the proposed retrieval is analyzed/tested…"
- Page 4, Eq. 1 and 2: Can you be more precise? These don't really help much…
- Page 5, line 8: fix unit format (1 nm) to be non-italic
- Page 5, line 9: Here, it would help (as mentioned earlier) if we knew more about the specMacs observations, for which the retrieval is designed. You mention that the mid-latitude summer profiles are taken, yet later on you mention that the retrieval should also work for observations in the tropics. Do you adapt the profile for these other measurements?
- Page 5, line 23-24: Is this part of the final retrieval? You perform simulations for two different CCN concentrations, yet this does not seem to be part of the Bayesian approach later on. How do you consider CCN concentrations, if at all?
- Page 6, lines 3-4: fix citation

- Page 6, line 6: So the model includes rain droplets? Maybe mention this explicitly, for some reason I thought this was a typo, because I initially only considered typical effective droplet radii up to 40µm or so…, this raises another question though. How sensitive is the retrieval to rain? Several studies show retrieval issues (TOA, bispectral) when there is precipitation in the clouds, as the vertical profiles and assumptions about gamma-distribution and effective variance fail.
- Page 6, line 26: reff and LWC are already defined
- Page 6, line 29: add comma after “As intended”
- Page 6, line 34: add space between “K” and “km”, add comma before “neglecting”
- Figure 2, this figure lacks “a)” and “b)”, so the caption is confusing, also the text mentions it shows reff, but it starts with LWP. Overall, very confusing to follow.
- Caption Figure 3: you not only show results for N_CCN = 1000 cm-1, but also 100 cm-1. Also, I am confused by the unit, which should be cm-3, correct? Please clarify.
- Page 8, line 8: remove “the”
- Page 8, line 11: add comma before “which”
- Figure 4: Again, this figures lacks “a)” and “b)”, and as far as I can tell, the “b)” part is not discussed at all in the text.
- Page 10, line 4: Change “found” to “retrieved”
- Page 10, Eq 5: change comma to full stop after the equation.
- Page 11, line 4-9: As far as I can tell you don’t show any cloud edge reff results. Also, no vertical gradients are shown to evaluate the “better agreement”.
- Page 11, lines 14-15. This sentence sounds awkward and I am not sure what you mean here.
- Page 11, line 16: add comma before “where”
- Page 11, line 29: This seems to be a really high optical thickness. Why did you choose that? From a TOA retrieval perspective, this is not really realistic. For comparison: the operational MODIS retrieval stops at tau=150, which is rarely encountered. Does the change in perspective (i.e., cloud side) yield this large limit? Please clarify.
- Page 12, line 9: “optically thick clouds” is very ambiguous. A cirrus is optically thick if tau>5, a stratus with tau> 25, a cumulus with tau>50. Can you be more specific?
- Figure 8: What is shown in the circles? What is the difference between grey and black lines? This Figure is very dense and includes a lot of information, it needs a better description.
- Page 13, last sentence: remove “Figure”
- Page 15, lines 9-10: This sentence is awkward.
- Page 15, line 12: change the last “,” to “and” or “to”
- Page 15, line 14: add comma after “Here”
- Page 15, line 16: pixels (plural)
- Page 16, line 11: define CMOS

- Page 16, line 32: pixels (plural)
- Page 17, lines 5-6: I don't understand this sentence.
- Page 18, line 13: add "a" before "viable"
- Page 18, line 14: again, "optically thicker clouds" is ambiguous. Can you be more specific?
- Figure 15: Can you combine Figure 15 and 16, with a panel a) and b)?
- Figure 17: why not show difference maps reff_ret - reff_true? While overall the retrieval seems to work well, differences for individual pixels can be very large.
- Page 25, bottom: 358,000 pixels (plural)
- Figure 18: This is very confusing: Figure 18 is discussed after Figure 20; the discussion includes results shown in Figure 19b. I had trouble following you here.
- Page 27, line 10: profiles (plural)
- Page 27, line 10: What do you mean by true? See also my general comment 5.
- Page 27, line 19: add "the" before "following"
- Page 28, line 3: pixels (plural)
- Page 28, line 4: add "," before "as well"
- Page 28, lines 10-11: remove the description of MYSTIC (already defined)
- Page 29, line 8: Especially in the conclusion you should be more specific about the applicability of the retrieval. What do you mean by "optically thick water clouds"? Are these values realistic, compared to field data? Earlier in the manuscript you mentioned tau=500, which seemed incredibly large to me. Is this the regime, where the retrieval works? When do the uncertainties become too large?
- Page 29, line 12change first "measurements" to "observations"

Literature:

Alexandrov, M. D., Cairns, B., Emde, C., Ackerman, A. S., and van Diedenhoven, B.: Accuracy assessments of cloud droplet size retrievals from polarized reflectance measurements by the research scanning polarimeter, Remote Sens. Environ., 125, 92– 111, https://doi.org/10.1016/j.rse.2012.07.012, 2012b.

Miller, D. J., Zhang, Z., Ackerman, A. S., Platnick, S., and Baum, B. A.: The impact of cloud vertical profile on liquid water path retrieval based on the bispectral method: A theo- retical study based on large-eddy simulations of shallow ma- rine boundary layer clouds, J. Geophys. Res., 121, 4122–4141, https://doi.org/10.1002/2015JD024322, 2016.

Miller, D. J., Zhang, Z., Platnick, S., Ackerman, A. S., Werner, F., Cornet, C., and Knobelspiesse, K.: Comparisons of bispectral and polarimetric retrievals of marine boundary layer cloud microphysics: case studies using a LES–satellite retrieval simulator, Atmos. Meas. Tech., 11, 3689-3715, https://doi.org/10.5194/amt-11-3689-2018, 2018.

Zhang, Z., Dong, X., Xi, B., Song, H., Ma, P. L., Ghan, S. J., Plat- nick, S., and Minnis, P.: Intercomparisons of marine boundary layer cloud properties from the ARM CAP-MBL campaign and two MODIS cloud products, J. Geophys. Res., 122, 2351–2365, https://doi.org/10.1002/2016JD025763, 2017.