General comments:

This manuscript presents a proof of concept for a method that can be used to retrieve cloud optical thickness and cloud fraction from multi-angle polarization observations. In particular from measurements at two viewing angles: one within the cloudbow at a scattering angle of approximately 140° and a second in the sun-glint region or at a scattering angle of approximately 90°. Further, the method consists of a look-up table generated using a 1D radiative transfer code. In addition, the authors provide information on the theoretical basis of their approach based on a limited (but sufficient) sensitivity analysis under idealized setups using the same 1D radiative transfer code.

Overall, the manuscript well suited for AMT and I believe the community can benefit from it. Also, the methods used seem to be robust and the language is fluent and precise. However, there some aspects of the manuscript that I am concerned about (see my comments below), and I believe are required to be addressed and clarified.

Specific comments:

1. The authors claim that they are presenting a retrieval algorithm that can be used to retrieve cloud optical thickness and cloud fraction from multi-angle polarization observations. Despite the authors' claim, the contents of the manuscript present the theory and proof of concept that the theory would work. Let me further explain this: an algorithm is defined as "a process or set of rules to be followed in calculations or other problem-solving operations". Here is an example to put things in perspective: you can have multiple lookup tables for a wide range of surface and aerosol characteristics, plus different cloud types. For this method to be called an algorithm, it must contain an automated mechanism to select between those lookup-tables. Or, for example, it should also contain automated steps for discriminating the cloud phase. I believe this issue can be addressed by either rephrasing the text and correcting the statement, or by developing the further steps required and expanding the simulations for the method to be called an algorithm. Also, the entire manuscript, including the title and abstract should reflect this matter.

2. Under real conditions, the measurements will contain some degrees of error associated with them. It is not clear how the instrumental noises are accounted for in the tests provided in this manuscript.

3. Given the fact that this manuscript is based on very few test scenes and idealized simulations, I find a bit difficult to understand why addressing the effects of the 3D radiative transfer should be a separate manuscript.

4. The analysis performed to evaluate the sensitivity of the responses to aerosols needs to be expanded to address as the total AOD is probably not the only affecting factor. In particular, the above-cloud-AOD, aerosol composition and size can also be important.

5. It is not clear whether the approach is intended to be developed for ice or liquid clouds or both. Also, whether for application over land or water. This has to be clarified along the manuscript including the title and abstract.

6. The authors claim that the approach is suitable for space-born multi-angle polarimetric remote sensing and they are waiting for the PACE data to become available. But it could also be test on the PARASOL-POLDER measurements (https://www.aeris-data.fr/catalogue/?checkBoxCriteria=%7B%22projects%22%3A%5B%22SPATIAL.PARASOL%22%2C%22SPATIAL.POLDER%22%5D%7D#masthead) as this data is available?

7. Adding some thoughts on how the authors are planning to validate the retrieved cloud optical thickness could be nice.

8. I believe, a viewing angle with a scatting angle that is exactly 90 and 140 degrees may not always be available. What is the protocol for such cases? Also, I see that the authors are using the word "approximately" in this context. It would be nice to add some words on the impacts of this non-exact scattering angles on the accuracy of the retrievals.

9. Some words on how the retrieval accuracy can be affected by using only the central band wavelengths and not applying the instrument response function can be beneficial.

Technical corrections:
1. In my opinion, the abstract does not well represent the contents of the manuscript (i.e., data used, theoretical analysis presented, testing performed and applications).
2. The story line in the Introduction section seems a bit off (sounds to me that some random information is being given to reader to fill the space) and can benefit from some revision. Here are some examples:
   a. The text given between lines 23-25 seems redundant or at least requires rephrasing. Also, I don't get how as the authors state the need for more observations is linked to algorithm development (that is the further exploitation of the existing data). Also, it does not connect well the previous and the next paragraphs.
   b. Something seems to be missing between the third and fourth paragraphs. And then it jumps from clouds to aerosols. And then jumps to clouds.
   c. Then the authors jump to giving information about the upcoming satellite missions.

3. It will be nice to have the hypothesis of the manuscript defined in the introduction and also specify why such a product is required / what this

product adds to the existing information.

4. The structure of section 2 is not very straight-forward and can benefit from some adjustments. Here are some suggestions:
    a. I would start the Methodology section with some brief information on what is it that is intended to be addressed and how (i.e., testing and explaining the theory behind the method, followed by the fact that synthetic measurements are produced …). Followed by two sub-sections that explain the methods for the theory and testing parts, respectively. Include all the methodology here, unless it is not possible.
    b. The sensitivity analysis performed seems like a result to me that explains the theory behind the approach. For this reason, I would create a new section 3 and dedicate it to the sensitivity analysis and call it something like "theoretical basis".
    c. The current section 3 can then be the new section 4.

5. It will be of a great importance to provide the bi-directional reflectance and polarization functions corresponding to the surfaces used.

6. Both "clear sky" and "cloud free" terms are used in the manuscript. Please harmonize unless the meaning is not different (in that case define it more clearly).

7. When talking about cloud layer height, is that cloud top height that you are referring to or base height?

8. Paragraphs 3 and 4 of section 4 contain plenty of unnecessary repetition of information that does not help concluding anything. Rephrase, shorten or remove.

9. Figure 5:
    a. It will be useful to have likes of Figure 5 for different land types somewhere in the manuscript (appendix would do as well).
    b. Write in the caption that the figure is for the case of ocean.
    c. AOD: is it AOD above cloud or total column AOD?
    d. It would make it easier to read the figure if you add just beside the figure (where a, b, c, … are) some small text that can be related to the parameter that is being evaluated. Example: a [tau]

10. Line 195: (tau_c), (c)
11. Line 196,197: are separated
12. Line 200: realize what?
13. Line 202: I believe what is important here is the cloud top height, not the base. Rephrase the sentence based on cloud top height.

14. Line 206-207: The sentence "P(110) …" does not seem to be based on the plot.
15. Info given in page 12 can go to the Methodology section explained above in comment 4.
16. Lines 201-202: explain the abbreviation the first time that the abbreviation is used. Also, do EUREC4A and HALO stand for something?
17. Line 236: the word "corresponding" seems strange there.
18. Lines 243-245: it is not very clear, please rephrase or expand.
19. Figure 6:
    a. Pannel names are difficult to see (font size is too small).
    b. The terms left and right are not very clear, maybe they could more clearly be labeled.
    c. Make the boarders of the shaded area more visible. It is hard to see it.
20. Line 255: total column AOD=0.08 or above-cloud-AOD?
21. Lines 268-269: omit "for this scene", and the second "which".
22. Line 287: Please further explain.
23. Line 282: comma is missing: palne, making
24. Line 298: comma is missing: ,for instance,
25. Line 331: MYSTIC?