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Atmospheric Measurement Techniques Discussions

Interactive comment on "Spatial distribution of cloud droplet size properties from Airborne Hyper-Angular Rainbow Polarimeter (AirHARP) measurements" *by* Brent A. McBride et al.

Brent A. McBride et al.

mcbride1@umbc.edu

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The authors thank Anonymous Reviewer #2 (AR #2) for their comments and review of the manuscript. The following author responses are given below the AR #2 comments for ease.

— AR #2:—

- P1, L13, "uncertainties" -> "sources of uncertainty"

- P2, L7, "depend" -> "depends"

- P2, L10, "are" -> "is"

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Discussion paper

- P3, L33 (and other instances). I would suggest replacing “confident” with some more specific terms (“precise”? “accurate”?)

Author Response:

These changes will be made as noted in the manuscript. All instances of "confident" will be changed to "accurate".

— AR #2:—

- P3, L42. Here, are you referring to retrievals only using one wavelength? What about using multiple wavelengths in order to partially compensate for the lack of angular resolution, exploiting the spectral shift in polarization features?

Author Response:

This line is talking about polarized retrievals done using a single wavelength, though one can use multi-spectral sampling to do as AR #2 suggests. The benefit of multi-spectral sampling is touched on briefly later in the same section. There is evidence in the literature (Alexandrov papers, Miller et al. 2018, Shang et al. 2015, our study, etc.) that a single wavelength is enough to retrieve CDR and CDV properties, as long as that channel samples the cloudbow with sufficient angular coverage.

We will make this more explicit by adding to the opening sentence (P3, L32, * is the change): " Multiangle sampling at high angular density and moderate pixel resolution are essential elements of a accurate, *single-wavelength* retrieval."

— AR #2:—

- P6, L23. Replace “will be launched in 2019” with the actual launch date (it has been recently launched, right?).

- P8, L10. Replace “>” with “<”.

Author Response:

The changes will be made as recommended. The HARP CubeSat launched on Nov. 2 2019. This will be updated.

— AR #2:—

- P8, L33-34. “The physics . . . beyond 1.5”. Why is it so? Please explain better.

Author Response:

We will add the following sentences in to P9,L10 before "Third, Breon and Goloub...":

"Because the x2red depends strongly on the uncertainty of the individual measurements, there is also a possibility that pixels that represent narrow size distributions may give a valid retrieval, while producing x2red values beyond 1.5. Figure 6a is one such example. The cloudbow oscillations are well-defined and AirHARP data clearly captures the pattern, though the x2red is 2.52. While the error bar on several AirHARP data points does not touch the best fit polarized reflectance, the overall curve fit does represent the information content in the measurement. It is therefore important to include the RMSE as a two-factor authentication. The RMSE evaluates how close the data points are to the best fit curve, with no regard to measurement uncertainty.

— AR #2:—

- P8, L37. Add “ratio” after “signal-to-noise”

- P8, L38. Can you briefly explain what optical etaloning is? As a non-instrument person, I don’t understand this sentence.

- P9, L30. Add “because” before “the solar geometry”

- P9, L37, “image-to-image” -> “from image to image”

Author Response:

Minor changes will be made as noted. Instead of adding an explanation on optical etaloning, much of which is outside the scope of the paper, the authors will add a

technical citation here for those seeking more information:

andor.oxinst.com: Oxford Instruments [online] Available from: https://andor.oxinst.com/learning/view/article/optical-etaloning-in-charge-coupled-devices (Accessed 14 Jan 2020), _____.

And will reference in-text as: (andor.oxinst.com,____)

— AR #2:—

- P10, L2. Do you mean that they tend to miss the angles near the upper end of the cloudbow range? Emphasize this a bit more in the sentence.

Author response:

Yes, but perhaps it is not clear enough. We will change "Targets observed outside these lines do not access the full cloudbow scattering angle range (<165°)." to "This work does not perform a retrieval on any targets observed outside these lines. Outside these lines, the reduced scattering angle coverage at the upper end of the cloudbow range begins to truncate the signal from the supernumerary bows. Because the majority of the size distribution information is encoded in the supernumerary bows (145-165 deg), it is important that the full scattering angle range is preserved."

— AR #2:—

- P10, L10. “the actual” -> “RGB composite images of the total and polarized reflectance measured”

- P10, L12. By "the actual image" do you mean the polarized reflectance composite?

- P10, L13-14. “The RGB composite”. Isn’t the total reflectance image also a RGB composite? If so, I would suggest to say "the polarized reflectance RGB composite" at the beginning of the sentence. Furthermore, does the lower panel of Fig. 5 only shows polarized reflectance, or is also total reflectance superimposed?

- P10, L22. By “standard deviation of the pixels” do you mean the standard deviation of their polarized reflectance?

- P10, L25, “forces a shift to” -> “causes a shift in”

- P13, L12, “the red line” -> “which is shown as a red line”

Author Response:

The authors will change "the actual image" and "RGB composite" in this section to "polarized reflectance image" for clarity. They are both RGB composites, as AR #2 notes. We apologize for any confusion here. Both images in Figure 5 are RGB composites, and total reflectance image is not superimposed on the polarized reflectance image.

And yes, AR #2 is correct in the interpretation of P10,L22. This sentence will be changed from "standard deviation of the pixels" to "standard deviation of the polarized reflectance measured at the pixels" for clarity.

All other minor corrections will be made as noted.

— AR #2:—

- P13, L11-13. What about the right hand sides?

Author Response:

Excellent catch, we recognize we did not explicitly explain those parts of the figure. The authors will add this segment after P13, L13 "...retrieval, the red line.":

"The two boxes to the right of each of the retrieved P12 curve plots in Figure 10d-f represent the retrieved CDR (middle column) and CDV (right column) for the colored superpixel boxes located in Figure 10a-c. The 600m CDR or CDV result is given in the title above each box and represents the retrieval for the entire 9-box square underneath, whereas the 200m CDR or CDV results are shown inside each colored sub-box.” We will also move the P13,L13 "Figure 10d shows that..." into the next paragraph.

— AR #2:—

- P13, L15. “Mischenko” -> “Mishchenko”

- P13, L27. At least “Fourier” should start in uppercase.

- P13, L30-31. By "well-mixed in CDV" do you mean that they reflect a more heterogeneous distribution of CDV values (I see values ranging from âĹij0.015 to âĹij0.15)? Say that a bit more clearly.

- P14, L10-11, “angle-to-angle” -> “from angle to angle”

Author Response:

All minor comments will be changed as noted. By “well-mixed in CDV”, the authors mean that there is a larger distribution of CDV values as compared to Figures 10d-e, not necessarily a heterogenous distribution. There are two meanings of heterogenous: the CDV value itself is a measure of droplet size heterogeneity in the pixel and a distribution of CDV values can be heterogenous if there are one or two clusters of values inside the same superpixel bin. It is important for the paper to be consistent to avoid confusion. When the word “heterogenous” is used in this work, it always refers to a high single CDV value in the retrieval (indicative of many droplet sizes existing inside the same pixel) or a visual variability in a cloud field. Here, the authors will rephrase this comment from “well-mixed in CDV” to “the retrieved 200m P12 curves show a wider spread of CDV values, as compared to the results shown in Figures 10d-e.”

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