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Comment on amt-2022-245

Bastiaan van Diedenhoven (Referee)

Referee comment on "High-spatial-resolution retrieval of cloud droplet size distribution from polarized observations of the cloudbow" by Veronika Pörtge et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2022-245-RC1>, 2022

This is a review of the paper titled "High spatial resolution retrieval of cloud droplet size distribution from polarized observations of the cloudbow" submitted to AMT by Pörtge et al. The paper describes the measurements of polarimetric cameras which are part of the specMACS instrument deployed on the HALO aircraft. The data processing is described, as well as the application of polarimetric cloudbow retrievals of the cloud top droplet size distribution. A few case studies are described in detail.

The paper is generally well written. The data and the results are very interesting and show a lot of potential. I recommend publication of the paper after addressing some minor comments and questions listed below and some corrections to the text and figures.

General comments:

- The data is corrected for the displacement of the clouds using ERA5 wind fields, as mentioned in section 3.2. As this correction seems not entirely trivial to me, I would suggest adding a bit more detail. For example, the ERA5 resolution is much coarser than the observations, so are the ERA5 fields interpolated to the observation locations? If not, I would expect strange effects at the ERA5 boundaries. (Please give the horizontal and vertical resolution of ERA5.) Also, how is the vertical variation of the wind field taken into account, as the cloud top height is not known yet at this step?
- If I understand correctly, the cloud top heights are first determined for cloud (parts) that show prominent features and those results are then interpolated to the rest of the field. Again, this interpolation seems not entirely trivial to me and more details are needed. Is it just a simple 2D interpolation in lat/lon space to the nearest points?
- In section 4.1., the detection of large cloud drops are discussed. In line 325 it is stated that the detection of these large drops "is confirmed by high reflectivity values of the polarimetric Ka-band MIRA-35 cloud radar measurements". However, this radar is sensitive to rain drops that are much larger than the large cloud drops observed by

specMACS. These cases likely have bi-modal size distributions, as discussed in the manuscript, but the large drops mode is not a rain mode, as suggested in line 333, but more likely drops in the 'size gap' as discussed in line 345. I think the discussion in the manuscript is a bit confusing now, somewhat suggesting the large drops are rain drops. I suggest rewriting the discussion to emphasize the distinction between rain and the large drops. Sinclair et al. (2021) also discussed the association between large cloud drops at cloud top observed with a polarimeter and rain detected by radar.

- In figure 13 an effective radius "profile" is shown. It is probably good to point out the profile is not a profile of effective radius inside a cloud, but statistics of effective radius at different cloud top heights. Some more details of how this profile is obtained would be good. For the interpretation, you may want to refer to Rosenfeld and Lensky (1998). https://journals.ametsoc.org/view/journals/bams/79/11/1520-0477_1998_079_2457_sbiiipf_2_0_co_2.xml
- In line 431-439 some reasons for the detection of large effective variance values, mainly at the cloud edges. It is suggested that errors in the aggregation of angles may have caused the cloudbow signal to be distorted. But would these cases not be filtered out by the RMSE and Qual requirements?

Minor corrections:

Line 24: These two sentences basically say the same thing twice. I suggest to remove the first sentence and move the IPCC reference to the second.

Line 53: Add "using the bi-spectral technique " after "is not possible".

Line 72: this should be "singly-scattered photons".

Line 75: I suggest changing the order of words into "which is a parameter that is directly linked to entrainment and mixing processes."

Line 80: An example of cloudbow retrieval applied to airMSPI is given by Xu et al. <https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2017JD027926>

Line 99: Please place a hyphen between 'bias' and 'adjusted'

Line 205: I think "from" should be "of" in this sentence.

Line 235: "the radiance measurement is binned". Do you mean Stokes parameter Q?

Line 240: "The P12 element is also called the polarized (single scattering) phase function and is a good approximation for the measured polarized radiance Q". The absolute value of P12 itself is not a good approximation of measured Q, but the relative variation is. Also, it is not Q, but Q rotated to the scattering plane. Please rewrite this sentence accordingly.

Line 245: The effective variance also determines the width of the secondary minima.

Line 294: Please place Eq. 8 here in the sentence.

Line 342: Please remove the comma after 'statement'

Figure 7 and 10: Please add some information about the (approximate?) scale to the figures. Either a scale bar or x and y axis labels.

Line 378: I suggest adding Zhang et al. 2012 as an additional reference.
<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2012JD017655>

Line 453: I suggest adding "to interpret" after "more difficult".

Line 475: A period is missing after "0.07".