Enhancing Consistency of Microphysical Properties of Precipitation across the Melting Layer in the Dual-Frequency Precipitation Radar Data

Mroz et al. 2023 submitted to AMT

Review by:

Anonymous Reviewer

Introduction and Recommendation:

Spaceborne radars provide unprecedented observations of the 3-dimensional structure of clouds and precipitation. The first meteorological spaceborne radar, named the Tropical Rainfall Measuring Mission (TRMM), was launched back in 1997, and enabled the first estimates of near surface precipitation rates across the global tropics. Through the years of TRMM, an emphasis was put on making the near surface rain rates more accurate. This emphasis carried through to the follow up mission, named the Global Precipitation Measurement Mission (GPM), which launched in 2014. The GPM mission extended spaceborne radar observations to higher latitudes with its more included orbit (65S – 65N).

The authors of the submitted manuscript have sought out to create a new radar retrieval specifically designed for the GPM Dual-Frequency Precipitation Radar and in stratiform precipitation. They show that one of the stock GPM algorithms (2A.DPR) do not have a physically consistent retrieval of precipitation rate through the melting layer (0 degC) which has been discussed in previous literature as a quasi-conserved parameter. Their main conclusions are:

1) Show the deficiency in the 2A.DPR algorithm for consistent retrievals across the melting layer.
2) Provide a new, optimal estimation, retrieval of DSD parameters.
3) Compare the new retrieval to ground based retrievals of the same DSD parameters.

The overall writing is good, and the paper fits the scope of AMT. I do have the following **major comments** that need to be addressed before publication.

Major comments:

Other GPM retrievals:
The author's center their discussion on the 2A.DPR algorithm, which is a primary product of GPM through the JAXA team. This algorithm uses a R-Dm-Ze relationship to retrieve the DSD (Seto) and the R-Dm relationship for snow is likely inappropriate (Chase et al. 2020). This is acceptable, but given the authors are providing a new retrieval, there should be some discussion around other published retrievals. The main other retrievals that come to mind are:

1) NASA GPM retrieval named the 'Combined' algorithm, which is first discussed in the literature by Grecu et al. (2016). The NASA CMB algorithm is an optimal estimation retrieval and might not have the same deficiencies as the 2A.DPR algorithm. The data are

freely available from the same website as the 2A.DPR files and potentially could be added into the analysis

2) The Chase et al. (2021) neural network retrieval. The focus of the Chase et al. (2021) retrieval was to correct for potential deficiencies in the 2A.DPR algorithm for snowfall (noted in Chase et al. 2020) and showed how the new retrieval compared to CloudSat in Chase et al. (2022). Furthermore, Chase et al. (2022; c.f., Figure 3), showed and discussed how the new neural network retrieval of snowfall rate, matches well with the 2A.DPR rain rate just below the melting level.

I know that adding in new datasets is cumbersome and is not needed for this paper to be published, but at a minimum there needs to be discussion of these two other GPM algorithms and the caveat that the issue noted in the 2A.DPR algorithm might not extend to the others.

Minor Comments:

Focus on Snow to rain transition

The whole paper has an emphasis on the snow to rain transition, yet the only evaluations done of the new algorithm is on surface rain (section 6). I get why this is done, to show that the new algorithm still gets sufficient rain accuracy, and the rain algorithms are generally better than snow algorithms (at least from NEXRAD). A suggestion here is reproduce Figure 3 with the new algorithm. This would really tie the point home that the consistency across the melting layer has been improved. Ideally this would be shown prior to the bulk evaluation (Figure 7). Can the authors also be explicit that the evaluations in section 6 are near the surface?

More details on the 2A.DPR algorithm:

It would be helpful to readers to have a bit more intuition of the 2A.DPR algorithm. For example, noting that it is an R-Dm retrieval, is helpful to provide context to the reader that the algorithm was developed for rain, not snow, and might be the main reason for the discrepancy the authors are highlighting in the manuscript. It would be good to cite the paper that describes the algorithm as well (Seto et al. 2021).

Length of record:

Why just 5 years of data? Why not use all of it (2014 – 2023).

Line by Line comments:

Note, word suggestions are *suggestions*. Please feel free to disagree.

Line 22: I have seen decent signal of the KuPR down to 12 dBZ. I know that this is not citable in a publication, but just a note.

Line 35: There is a better citation for the Conv/Stratiform retrieval: Awaka et al. (2021)

Line 52: Maybe the word ‘stratiform rain volume’ is better than ‘stratiform rain deck’

Figure 1 caption: Which ray is this? Is it near nadir I assume?

Line 84: I know that aggregates have large non-Rayleigh effects, but is this common knowledge? Should you cite an example here?

Lines 93 – 96: it might be good to mention here that prior to May 2018, there was no matched Ka-band in the outer swath anyway. Making the identification of the bright band harder and no Ka-band for the dual-frequency retrieval anyway.

Line 99: This would be a good spot for the Le and Chandrasekar (2013) reference.

Section 3: This is where some added discussion on the R-Dm retrieval in the 2A.DPR product would be helpful (Seto et al. 2021). Furthermore, it might be good to mention Chase et al. (2020) which evaluated the R-Dm relationships in rain and snow.

Line 174: Can you add 2A.DPR in parenthesis after the V06? This would help folks who know more about the DPR algorithms what files you are using.

Lines 178 – 181: This was noted previously by Chase et al. (2021; c.f., Figure 15).

Lines 212 – 213: The Skofronick-Jackson et al. (2019) and the Casella et al. (2017) papers also documented the snowfall rate deficiency of the 2A.DPR algorithm.

Line 375 – 376: There is a good reference by Heymsfield et al. (2018) that talks about the relative humidity across the melting layer.

Line 463: Refrain from using the word 'significant' unless a statistical test is used. If there was a statistical test used for hypothesis testing, be explicit which ones and what level of significance was used.

Line 464: Suggest switching the order of rain and snow to follow a top-down (i.e., snow falling and melting to rain).

Code Availability: It would be nice to have a simple script to show how to run the OE retrieval developed in this paper. That way readers could run the suggested physically consistent retrieval for their respective scientific endeavors.

References:

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Heymsfield, A., A. Bansemer, N. B. Wood, G. Liu, S. Tanelli, O. O. Sy, M. Poellot, and C. Liu, 2018: Toward Improving Ice Water Content and Snow-Rate Retrievals from Radars. Part II: Results from Three Wavelength Radar–Collocated In Situ Measurements and CloudSat–GPM–TRMM Radar Data. *J. Appl. Meteor. Climatol.*, **57**, 365–389, https://doi.org/10.1175/JAMC-D-17-0164.1.

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