Review Xie et al. „ZJU-AERO V0.5: An Accurate and Efficient Radar Operator Designed for CMA-GFS / MESO with Capability of Simulating Nonspherical Hydrometeors “

The paper presents the radar forward operator ZJU-AERO that is capable of simulating radar observables for both ground-based and air-/spaceborne sensors and of considering effects of non-spherical, non-homogeneous hydrometeors incuding polarimetry, designed particularly for use along with the Chinese Meteorology Administration’s numerical weather prediction models. A larger fraction of the paper deals with evaluation of the Chebyshev shape model for rain suggested by Chuang and Beard (1990) compared to more classical spheroid models.

In general, this topic is suitable for publication in GMD. However, the paper “oscillates” between some very basic, textbook-like descriptions entangled with some quite specific, not always relevant details, but lacking clear direction and clarity and detail at places where it would start to be really interesting. I suggest publication to be considered after major revisions.

Please find below my detailed review report.

General remarks

The manuscript, in my view, presents a mixture of on the one hand quite basic, but very detailed content and on the other hand seemingly more novel, but hurried over, too superficial content. It seems to me like an extract from a thesis, with individual parts not stitched together very well for providing a consistent and concise work with a clear common thread. It contains a number of rather fancy illustrations that, however, do not necessarily provide relevant information, and that often are not covered with appropriate detail in text, ie that rather seem to be there to look nice than to make a relevant contribution (eg Figs1, 4, 5, 6).

It often remains unclear what has been done by the authors, what has been by other work, and what has been taken over quite directly from other works (general approaches, more specific methods, algorithms, possibly even code, …), and how particularly the latter has been incorporated into this work. For example, L139 refers to Zeng16 for sub-beam sampling and averaging methods in submodules B1 and B2 in a way that seems to imply Zeng16 describes a part of ZJU-AERO (“see Zeng et al. (2016) for more about”); however, Zeng16 describes another, independent radar forward operator (RFO) and it remains unclear whether the reference is “just” to a general approach or to specific formulas and their implementation or to the taking over of entire code bits. Similar for the Wolfensberger and Berne (2018) reference in L146. Also, L309 “To address these uncertainties, a field research study was conducted” also at best leaves it unclear whether the study was done by the authors (that’s what this formulation suggests to me) or others. So please be more clear in your formulations!

Improve presentation style:

- First present results (describe them), then discuss / explain them, then conclude.
- Figure contents, when shown, need to get presented and discussed, otherwise leave them out (e.g. polarimetric variables).
- Equations should always be integrated in text, ie be part of a sentence that makes sense when being read out loud, not stand alone and/or a few lines before or after they are introduced.

- Introduce math symbols at first use. Use unambiguous notation, e.g. avoid to use λ for both radar wavelength and PSD parameter, Dmax for maximum diameter (or max dimension?) and upper PSD integration limit, …
- Introduce acronyms at first use. Then use them, without re-introducing.
- Figure captions here are generally overlong with partly redundant or irrelevant content. Figure caption are supposed to describe what is seen in the figure. All details on data processing, implementations, setups and the like should instead be in the text.

Improve language:

- Spell-check.
- Use tenses consistently throoughout the manuscript. For things done in this study and presented in this paper: either present or past; I suggest present tense.
- Be careful with fill words (e.g. “however”, “nevertheless”, “fortunately” (?!?), “It is worth to note/mentioning”, “obviously”, …) that inappropriately (unintentionally?) relativize or judge.
- e.g. L108: what is an “approximately(!) 4/3Re-radius curve”? L110 “rarely” rather “weakly” or “negligible”, …

Specific remarks

Abstract: It introduces ZJU-AERO as polarimetric RFO with one main objective bein the assimilation of ground-based radar polarimetric variables. The remainder of the manuscript, however, has little on polarimetry – it introduces/defines the variables, presents some calculations, but without any relevant discussion of them.

Introduction: It might be worth mentioning Zhang21 in the state-of-the-art review of RFOs, too, as it targets fast applications like data assimilation and contains a melting scheme module.

L48f: “Zeng et al. (2016) […] but it focuses on non-polarimetric variables.” – Recent versions of the Zeng et al. (2016) RFO EMVORADO also cover simulations of polarimetric radar variables (see Trömel21, Shrestha22).

L131ff: As this covers two distinct submodules, B1 and B2, make clear in the text which descriptions belong to which submodule.

L147ff: Where is the input to module (D) taken from? User set? Model driven?

L149f: “regular morphology […] an analytical expression can then be used to retrieve the PSD” – Too specific at this point in the manuscript, where it is everything but obvious what particle morphology has to do with PSD.

L153ff: Which module does this? Language/grammar of this paragraph needs care.

L158: Does this module have a letter-name? “calculates intrinsic polarimetric radar variables on each radar gate” – Wouldn’t that rather be on each subbeam-gridpoint within each radar gate, or where is this done?

L153ff: Do numbered items 5.-7. all belong to module (E)? If so, better make them subitems 5.1-5.3?

Fig2: It is unclear, how module (E) links to the multi-level database (and remains so throughout the manuscript): Is the DB external and can other DB be used, too (e.g. the ARTS-SSDB by Eriksson18)? What data would they need to provide? Does module (E) get LevelB data? Why cover LevelC here then? Where does LevelA->B conversion gets its settings/assumptions on orientation preference and shape parameters from? Is that hard-coded?

L173ff & Fig3: This does not seem particularly relevant. If relevant, give it its own subsection at an appropriate place in the manuscript. Under “Flow Chart and Concepts” it definitely seems out of place and far too specific.

L195ff: “Since those topics have already undergone sufficient discussions in other works concerning radar operators, and we just inherited those settings and options from them. Readers with an interest in these options may refer to the bibliography mentioned in the ZJU-AERO general workflow description text.” – That’s far too general and not appropriate for a scientific publication as this does not facilitate reproducability of your research. You need to reference clearly, which parts come from which reference and specifiy what “inherit” means in each case (general approach, specific methods, implementations, …).

Sec2.2: Most of the time I appreciate when papers provide sufficient and clear theoretical background. So I have ambiguous feelings about criticizing this section. However, it seems a bit too basic and too drawn out textbook knowledge. Beside that, it’s incomplete: What is L (L209), what are the h, v, k (L215)? It jumps from theoretical background to very specific ZJU-AERO things (database Level A/B units). Figure 4 does not (at least not to me) “explain why the BSA convention should be introduced” – as the reader, I don’t care whether it “should be introduced” – just that you introduce it (if it is relevant).

L227: “we also have the 4x4 real matrix” – formulation. “one can define”? what are the actual properties of S and of Z and K, what’s the difference, what are their respective roles/uses? what is “the Stokes vector space”

L238: This paragraph doesn’t make sense to me. Maybe a language issue? What’s the role of the optical theorem here? “This is because” – what exactly is because of what?

L243ff: I find conversion formulas S -> Z,K actually more relevant than providing radar variable formulas in terms of S.

L265: What is the tilded rhohv? “is the magnitude of […] whose amplitude is” – i might be off, but in my understanding the amplitude is the magnitude of a complex number. So why would they be two different variables (tilded rhohv and deltahv)?

L279: What’s the difference between “reflectivity factor” and “reflectivity”? The path attenuation?

Tab1: Shape distribution information is missing here (in text, Wolfensberger and Berne (2018) is given, ie Garrett et al. (2015) can’t contain this).

L316: “in which y is the reciprocal of the aspect ratio” – Define what aspect ratio is for you. There are different definitions around. Compare, e.g., Ryzhkov’s (minor axis / major axis, ie AR<=1) or Mishchenko (rotational axis / symmetry-plane axis, ie AR<1 for oblates, AR>1 for prolates).

L321: “The mass–diameter relationship is crucial in determining the PSD” – why?

Sec2.3: For rain, is there also a shape distribution assumed?

L336: “it seems that a microphysics-consistent mass-diameter relation […]D_{max}^3 for snow and graupel” – it seems??? how would D_{max}^3 be microphysics-consistent? What is rho_sp?

Eq22: That doesn’t make sense to me. In this notation $F(\lambda)$ will be 0. What are F and F’ anyways?

L355: What is V, where do you get that come from?

Sec3: There is far too little information on how the database is constructed, e.g. how many/which grid points are used for each of the dimensions, what are the integration limits etc. And how that has been decided. And how much impact that has on the final radar variables.

L366: “This shape differs from the traditional spheroid shape commonly used in other radar observation operators. Therefore, in this section, we will delve into the design of the database” – Why is that relevant for the DB design, i.e., how does that affect the DB design or is a good example for it? Moreover, where design is discussed (subsecs 3.1 and 3.2), it’s neither relevant whether it’s rain or any other hydrometeor category nor what the shape model is. On the other hand, subsections 3.3-3.5 do not present or discuss DB design, but evaluate the contents of the DB.

L386: “of the lookup table (stored in netCDF4 format)” – Are all DB Levels stored in one table/file?

Tab2: “that a single database for one hydrometeor and once frequency occupies” – what is a “single database”? As opposed to a (single) lookup table (file)? Does “one hydrometeor” refer to one hydrometeor class (ie all sizes) or a single particle size?

Tab2: Angle brackets typically indicate integrated variables. Note, that even RSSP and ASSP Z and K in your DB are already integrated (over azimuthal orientation and shape/canting distributions, respectively), ie they should technically have angle brackets, too.

Tab2: Are the full 16 elements of both Z and K kept (since only the diagonal 2x2 blocks of Z and only 3 entries of K are used)?

Tab2: How are the different PSD handled in the DB? Separate tables (files) (or DBs?)?

L396: This whole paragraph seems rather basic. Or standard. A textbook reference, eg to Mishchenko, would suffice in my view (but references are urgently needed in any case!). It stops to elaborate, however, where it would get more interesting, e.g. how the reference orientation is set for prolate or for irregularly shaped particles.

L404f: “ZYZ convention” is at least ambiguous since there are two coordinate systems with unidentical axes, ie with respect to which of these axes (L- or P-system) are the rotations performed?

L408: What is meant/referred to by “arbitrary orientation preferences”? Do you mean arbitrary orientations (but that wouldn’t cover numbered item 4)? or actually orientation preferences, but numbered item 4 is neither arbitrary (random in alpha and gamma is already quite specific).

Eq(24): Standalone equation without any referring text??? Why X has one and two overline(s) here, but Z and K don’t have in Tab2 RSSP and ASSP entries, respectively?

L432: “Eq. (25) gives […] Level A to Level B database conversion tool” – p(beta) given here is not general, but specifies a Gaussian distribution in polar angle with standard deviation sig_beta.

L434: “It is important to consider particle symmetry” – Not that important, in my view. One can save a bit of computational resources, but results will still be correct when symmetries are ignored. However, it is far more important – and relevant for ensuring correct results – to not accidentally implicitly assume any symmetries in arbitrary particle shapes (considering or neglecting flipped and/or mirror-symmetric counterparts).

L439f: “a more accurate […] commonly used spheroid model” – add reference for this statement (Ekelund20 rather concluded that Chuang and Beard model is no significant improvement at least regarding radar reflectivity compared to the spheroid model)

L442: “The obtained results were then fitted […]” – by whom? Are you still summarizing Chuang and Beard (1990)? Or is this your own work? Reference properly – this applies to the whole paragraph, actually (if it’s all Chuang and Beard, reduce to only repeat the crucial info and refer to Chuang and Beard for the rest – e.g. why are the truncation and the Deq range and spacing in the coefficient calcs relevant here?)

L452: “Comparing […] with significantly different aspect ratios is meaningless” – Why is that? Predicted radar variables (for a given D or PSD) are the relevant parameters to be compared,

regardless of the underlying aspect ratio, or the maximum dimension, or any other possible affecting particle property. It is interesting, though, to understand which and how impact each of the properties contributes.

L458: “Therefore, we can confidently assert” – I do not fully agree as this does not provide info yet on how much difference in SSP results from such seemingly small diffs in gamma. Only comparing SSP of particles with equivalent gamma and Deq could provide that confirmation.

L460: Does equal Deq imply equal Dmax (i.e. a=a’)? Hence do diffs in gamma exclusively result from differences of minor axes b and b’?

L467: “The initial examination […] by Ekelund et al. (2020)” – Reformulate. This seems to imply Ekelund20 were the first to study rain drop SSP (I’m not even fully sure, they were the first using the Chuang and Beard and/or the Chebyshev model – actually, Aydin gives a short summary of Chuang and Beard effects in their Chapter on cm- and mm-wave scattering from hydrometeors in the Mishchenko00 book).

L468: “they used a modified version of the EBCM code” – modified in what way? Ekelund et al. themselves state they used “the Fortran T-matrix code developed by by Mishchenko (2000)” and don’t mention modifications.

L471: “To ensure […] a user-friendly radar operator interface, this study presents an optical proerty database […] using the IITM code” – Check language: is it really that presenting the study ensures those things? What does user-friendliness have to do with shape model and T-Matrix code applied?

L479: “raindrops with their Deq larger than 8mm disperse easily” – Provide a reference for this statement. Ekelund20 argue with 5mm, supported by two references.

L482: “we need to introduce intermediate quantities called the SSP factors” – Why do you NEED to introduce them? You just chose to (hopefully because they are illustrative and facilitate understanding). However, what do you mean by “SSP factors”, what are they? Explain!

L483: “The SSP factor [zhv] for the unpolarized reflectivity” – Why using unpolarized reflectivity when radars ALWAYS measure a specific polarization? Using hv as subscripts in z seems a bad choice since zhv usually refers to horizontally transmitted/vertically received reflectivity occuring as the nominator in the definition of linear depolarization ration, LDR.

L486: “enable us to assess the contribution of particles with a diameter Deq to the radar reflectivity” – How? Provide a proper explanation of what the SSP factors are. And isn’t that, ie “contribution of particles with Deq to reflectivity”, what backscatagrand later will provide?

Fig8/Fig9: Looks fancy, but would a simple cartesian plot not suffice, be easier to digest and be less prone to biased interpretation? Particularly since the center of b) panels is not 0, but 60 (ie deviations are even smaller than they appear here). Radial axis of a) panels is unclear – it’s neither linear nor true logarithmic, isn’t it? (also, the middle value, I guess, should rather be 5.10^2 instead of 5.10^3). Displaying z-equivalents in log scale (ie dB) seems more suitable than linear scale (ie L^2 units) to judge relevance/significance of differences in radar applications. Why are you showing the elevation range, apart from -30 to 30° masked sector, twice? That’s not symmetry, but identical parameters elevations!

Fig8: Why is T-variation relevant to show? (Is variation with T entirely due to temperature dependence of refractive index, or are there any other T-dependent parameters?)

L517ff/Fig8: “we found that the [zhv] factor for ground-based observation geometries (e=0~20°) was significantly weaker” – First, differences at e=0° seem (close to) 0 to me. Second, what differences do you consider “significant”? I find them anyways hard to judge in linear units, this would be much easier in dB units.

L524ff: “demonstrate the stability of the deviations […] in terms of the temperature […] However, the finding is different for [zhv] against the orientation preference” – Yes, of course. Varying orientation present a significantly different (geometrical) cross-section to the observer, while varying T (apart from phase changes) essentially keeps the same “view” of the roughly same particle.

L528f: “Fortunately, the column ‘orientation preference’ in Table 1 shows that the standard deviation of beta=7° did not exceed this threshold for raindrops.” – Fortunately? First, consider language: fortunate might be that rain drop tumbling is typically small, but it hasn’t to do with fortune that your Table shows the value it shows (I hope at least; or did you throw dices?). Second, why would higher sigma be “unfortunate”? And what would you do in such an “unfortunate” case, like eg in strong turbulence cases?

Fig10: That is quite a rich plot. Considering that, there is very little presentation of its content and discussion/interpretation of it in the text. Particularly, there is practically none at all on the polarimetric variables. Without that, skip the respective plots/panels.

L540f: “focus on describing the PSD options […] (namely, ASSP to BSP conversion” – This subsection is supposed to be about DB Level B, i.e. according to Fig.2 the orientation and shape distribution averaging. Hence unclear why PSD appears here already.

L542: “a total of six options for PSD schemes for raindrops […] listed in Table 3” – Inconsistency? Tab.1 only lists 4 options?!

Tab3: Meaning of x1 and x2 parameters to be introduced/shown by an equation. What is the relation of the six schemes listed here to the Cx schemes listed in Tab1?

L572: “Figure 11 demonstrates that the uncertainty of intercept parameter No […]” – How? Explain better. Do you really mean uncertainty? Or rather spread among PSD schemes?

L572: “Thompson scheme […] priorities smaller drops” – prioritizes. Can this be seen in Fig11? How?

L575ff: “For example, stratocumulus […] production of unusual PSDs” – I do not understand what you are trying to say and what this has to do with PSD in RFO or even with DB Level B/RSSP.

L579: “we introduced the concept of ‘backscatagrand’” – Language/writing style: You didn’t introduce anything yet, you are going to do that now. Don’t announce that, but do it. Not just by naming it and already pointing to results, but EXPLAIN it. The current attempt on explanation (L583ff) is too confused, too little to the point.

Fig12: Include Thompson tuned here as it is used as the basic PSD in Sec4 (there even before discussing the need for and approach of tuning).

L604: “It can be concluded from Figure 12” – Before making conclusions, present the results and discuss them.

L609: “unique to modern PSD schemes” – Is it? Why? What defines a ”modern” PSD scheme? Is T08 one or not? Besides, though not exactly coinciding peak & dip for MP48, backscatagrand still exhibits a kind of dip (or hiatus in its decrease).

L610: “leading to a loss of bulk reflectivity” and L615f: “T08 scheme must be much smaller” – Would ease discussion (by reducing unnecessary speculation), if you not just state, but show that. E.g. indicate resulting bulk zhv for each PSD and QR in the Figure 12 panels (lower row), e.g. by a symbol at placed at end of x-axis.

L617: “relative importance […] can also be diagnosed with […] backscatagrand” – that’s its ultimate purpose!

L625: “we made speculations” -> “we hypothesized”. However, it would make for a smoother read if you avoid the need for hypothesizing/speculation by already presenting the resulting equivalent bulk properties belonging to the Figure 12 curves.

L627ff: Which of these conclusions actually require/are affected by the chosen shape model? How do your findings on Chebyshev shape model compare to Ekelund20’s findings?

L642f: “sensitivities of polarimetric intrinsic radar variables […] were not examined in this paper” – Then there is no reason to present them at all!

Fig13: Is presenting polarimetric variables for close-to-nadir angles useful, or aren’t they more interesting in ground-based measurements? Why only 3 PSD schemes included here? It might be more useful to present ZH and ZV separately (though not necessarily for for close-to-nadir observations).

Sec 3.3-3.5: What do these subsecstions provide beyond what Ekelund20 already did? That is, what justifies this lengthy presentation (it’s 10 pages, ie ¼ of the whole manuscript). Particularly since Ekelund20 concluded differences in reflectivity from Chebyshev and spheroid shapes are negligible for ground-based weather radars and still pretty small in nadir-viewing geometries.

L668: “has switched its scan pattern” – How was it before? And/or how is that relevant here?

L678: “the structures […] are described as contiguous and vague” – rather “appear more contiguous and vague”? Is this from visual impression or any quantitative measure?

L681: “simulated radar reflectivity should be unbiased […] we assume […] was roughly unbiased” – Are the reflectivites unbiased? Analyze and show! On what grounds do you assume the model to be unbiased?

L685f: “observations revealed a prominent bright band” – Really? Where? I can’t identify that. Prominent BBs aren’t particularly common in inhomogeneous atmosphere states.

L689f: “it was expected […] have a positive OmB signature” – Why? Due to model lacking melting scheme? Be clear.

Fig14: What RFO setup is used here? Describe in text, not in figure caption!

L698: “altitude levels(namely, 0, 3, 5, and 8km)” – Isn’t 0km in the blind zone?

L700: The post-processing information should go into the text and be described more clearly.

L713: “a minor negative OmB bias was observed” – Visually or using any quantitative means?

L713f: “which could be attributed to the over-attenuation” – What is over-attenuation? Why does it occur in Ka, not Ku? And only in simulations, not observations? Actually, it hasn’t been made clear whether attenuation was considered in the simulations and whether the GPM observations used here were corrected for attenuation affects or not.

L718: “The OmB plots […] useful tools for verifying and calibrating new observation operators and identifying their deficiencies” – How do you separate observation operator deficiencies from NWP model deficiencies?

L719: “the bias of distributions is reasonable and demonstrates the capabilities” – You did not really present any distributions (ie statistics)? Just scene snapshots.

Fig16: Why not binning simulation data equivalently to observations? Why showing 4-6 and 6-8km layers when not relevant for comparing rain PSD (and shape model) effects?

L734: “Based on statistical analysis” – why not showing the PDF of QR?

L738f: “As a result, applying the Thompson2008 PSD could lead […] (Figure 13)” – Rather “According to Sec…/Fig.13, …”. Could? Under which conditions? Or does it?

L745: “Fortunately, we identified an optimal point” – By luck? Describe the tuning procedure.

L754: “However, we still believe that the CmS effects could be” – Reformulate. Believing is a bad argument in science. What supports this believe? References cited by Ekelund20, however, suggest that drops do not get larger in heavier storms, but break up instead and form more smaller ones.

L760: “demonstrated the data analysis tools in each layer” – Which layer? Which tools? You presented some analysis of rain drop DB data, but not any tools.

L765ff: Instead of a lengthy and fairly uncertain to-be-done wishlist, I’d prefer more summary of main findings of the analyses. Like a statement whether considering more sophisticated shape models than spheroids is actually really relevant.

L765: What is “geometric characterization”? Before dealing with melting particles, presenting frozen hydrometeor modelling seems more appropriate.

L777: “modules to interface with the data” – How does that fit (or where are these indicated) in Fig2 Flow chart?

Spelling & other minor things

L48: Remove second “described”.

L78: Add reference for PMR and DPR properties (a more current one than Iguchi03, covering the instruments that are actually flying).

L79ff: Add reference for PR2 and RM constellation (what is RM, by the way?).

L83: “This study is organized into …” – rather: “This paper is organized as follows.”

L110: “rarely” rather “weakly” or “negligible”

L128: “This step facilitates” – In the meaning of “prepares for” (things done in module (C))?

L147: “specifies the settings of hydrometeor” – rather “properties”? Hydrometeor<u>s</u>.

L167: “would be performed” – is? The whole “If” seems unnecessary – if N=M=1, then is can simply be seen to be performed over 1x1 pts.

L197: “At this point, we should” – This sentence should, if there at all, be at beginning of Sec2.2. Further, why “should” you?

L244: “Svv/hh” – wrong order of subscripts? It’s not zh that is a function of Svv, but zv, is it?

L249 and elsewhere: “without dimension” -> “dimensionless”

L256f: Either use two separate equations for ah and av or use ± and ∓.

L262: In my understanding, that angle symbol typically rather indicates phase, not amplitude (see e.g. Wikipedia on complex numbers). Why not use the explicit calc formula as in zh and rhohv calcs (ie |x|)?

L264: “radii to deg. Again.” – typo?

L316 and elsewhere: “possibility distribution” -> “probability distribution”

L322: “the hydrometeor category follows” – which hydrometeor category?

L326: “is a prescribed constant in the microphysics package” – which microphysics package? of ZJU-AERO? the CMA-NWP?

L330: “solve the unknown parameter λ“ – provide λ formula here, not 5 lines later (equivalently Eq(19) already belongs at “given the mass concentration” just before).

L360: what are BSP and SSP? First occurence, so spell out.

L361, 365: “now”: what is that supposed to express?

L405: “we could uniquely determine” -> “any arbitrary orientation of the particle can uniquely be determined”

L407: “With a specified orientation and observation geometries” – Check grammar. Also, terminology is uncommon (“observation geometry” involves an observer in my interpretation, here it’s rather the scattering geometry).

L409: “We used the T-matrix code” – I assume, here not the (or any specific) code is meant, but the T-Matrix approach or method.

L427: “the particle with original orientation” – original? Do you mean the reference orientation (alpha=beta=gamma=0°), ie where L- and P-system are oriented identically?

L442f: “as shown in Eq(26)” – put Eq(26) here and integrate into sentence.

L451: “more prone to aerodynamical effects” – meaning? why relevant here?

L481: “it is necessary to visualize” – To analyze, I agree. But that does not necessarily require visualization.

L485: “often referrred to as […]” – Provide reference.

Eq(27): Check notation in equation. Really zhv == <[zhv]>, ie the SSP factor for the unpolarized reflectivity is equal the unpolarized reflectivity itself?

L495: “The beta dimension in the database are fixed at 0°” – Rather, the database entries for beta=0° are shown, while beta dimensions has more entries as suggested by Fig9.

L500: As L495, T was not fixed in the database, I assume, but the results for T=10°C shown here.

Fig10: In caption, explicitly point out which SSP factors are shown in each panel (particularly, info on what is shown in row 1 vs row 3 is missing).

L516: “This phenomenon […], which is likely attributed” – Ekelund20 attribute it to that.

L539: “show a minor decay”: Minor deviations/differences compared to beta=0° results? Or what is meant by decay?

L550: “Among the six schemes, group A is characterized” – First introduce that you distinguish two groups before characterizing each.

L564: “by assuming q_air=[…] of standard atmosphere” – At pressure of…?

Fig11: As RWC lines are only background information, present them less prominently (thinner lines, uncolored lines? or maybe as weakly coloured filled contours?). Could PSD scheme curve style be selected to make groups A and B easily distinguishable?

Fig12: Indicate more clearly in the upper-row panels that black & red curves are m(D)N(D) measuring on lefthand y-axis, while blue is sig_bsc/M(D) measuring on the righthand y-axis (e.g add blue in legend. and/or color the sig_bsc/m(D) formula in the top right of the panels blue). Axis labels and legend text should be increased to a readable font size.

Fig12: Use identical Deq ranges on x-axes over all panel for better comparability. Maybe scale lefthand y-axes (upper and lower panel) by QR to make shape of PSD better comparable.

L598f: “while the single-particle unpolarized backscattering per unit particle mass sig_bsc,hv(D)/m(D) is indicated” – Use the previously introduced (L592) terminology ‘mass backscattering efficiency’, otherwise you add confusion.

L602f: “Readers can verify that the” – Remove that unnecessary and odd intro (reader anyways cannot; they can at max roughly qualitatively guess), simply leave the following statement.

L605: “exhibit large uncertainties” – Are these indeed uncertainties? Or, simpler, differences?

L612: “Under moderately heavy precipitation conditions […] outlier” – Under all but the heaviest conditions, actually.

L614: “even though” -> “while”(?)

L663: “GPM-DPR’s Ku-band radar is similar to” – meaning what?

L665: “accurate estimates of DSD can be obtained” – rather “more accurate” as they still have uncertainties. Reference missing.

L670: “defined as the difference” – of log space reflectivities, isn’t it?

L684: “freezing level […] was found within” – in obs or model?

L686f: “It’s worth noting” – Why? How is this relevant here, telling me what?

L694: “We plan to report […] in upcoming publications” – Rather “Implementation of […] will be subject to upcoming publications”

Fig14: Color scale with quasi-white region (around 18dBZ) seems not the best in combination with a white background.

L711: “The radar operator […]” – Remove; it doesn’t belong in caption and is redundant anyways.

L752: “Not surprisingly” -> rather “As suggested by results in Sec3”

L762: “assessments of PSDs and morphology options” – Add: for rain.

L835: Geer et al. has long ago been published as proper GMD paper. Update.

References

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