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Atmospheric Measurement Techniques Discussions

Interactive comment on "Microwave single scattering properties of non-spheroidal rain drops" *by* Robin Ekelund et al.

Anonymous Referee #1

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The authors describe a new database of microwave scattering properties with three raindrop shapes at a large variety of frequencies, with the focus on non-spheroidal drops. This work follows on from a similar database created by the authors for ice and snow scattering properties. It is relevant for this journal and could be another useful reference in the literature as the microwave radiative transfer community moves increasingly towards more sophisticated microphysical modeling and assumptions.

The layout of the paper is simple and effective, and the conclusions of the authors seem quite reasonable. My main concern with the paper lies in its argumentation and justification of its methods. The title implies a more systematic treatment of non-spheroidal drops, but in fact only one is selected and studied; this is not a problem per se, but it requires more justification than provided currently in the manuscript. Similarly,

the paper's analysis and conclusions are predicated upon the Wang et al. DSD, but the choice of this particular DSD is not justified whatsoever. The lack of justification is one thing, but the choice struck me as odd given that there are far better known DSDs out there, whereas the Wang et al. parametrization is not widely cited and is unlikely to be familiar to many readers of this journal. If there were some discussion of the results' sensitivity to DSD assumptions that might be alright, but it is not treated in the manuscript as it stands. Lastly, temperature of raindrops is included in the stratification of properties, but this is not discussed at all, leaving the reader wondering if it has any impact or not.

My recommendation is for the paper to be revised to better justify its approach, potentially with more analysis added if warranted by significant sensitivity to the DSD chosen. So this falls perhaps between major and minor revisions recommended, but it may become more major if the authors deem it necessary to include more discussion of the temperature sensitivity, DSD sensitivity, or other non-spheroidal drop models; I cannot comment on that because it remains to be seen how significant such sensitivities are to the study's conclusions. My remaining comments are split up into larger issues to be explained, followed by more minor/textual comments given by line number.

1. This is semantic, but throughout the paper and even in the title, I would suggest 'raindrop' should be the standard usage. Right now it varies between 'rain drop' in most circumstances, 'rain-drop' (L77), and 'raindrop' (L153). It would of course be picked up by a copy editor later in the process, but since it's in the title I thought it worth mentioning.

2. Justification of the Chuang and Beard drop model being the only non-spheroidal model chosen for the database is simply that it 'was selected' (L77), as it showed 'good agreement' with observed drops in a subsequent study. This needs to be expanded. Are there competing non-spheroidal drop models out there, or was the be-all-end-all drop model developed back in 1990? I'm not being facetious – it's just that the lack of context and justification seems to imply this level of certainty. It also underlies the title,

which implies that this model is at least representative of non-spheroidal drops when it comes to SSP. Is this true, or does the title need some adjusting?

3. Temperature is included in the database with five values from 230 to 310K. Is it useful or even responsible to include 230K raindrops? Do these ever exist in nature as pure water? Please justify this range with some references and discussion, as currently it seems to be blindly following what was used in the ice particle database previously. Furthermore, there is no discussion of whether SSPs change with temperature. Would my results be garbage if I used the 230K SSP data instead of 290K for raindrops? This would be very useful information for any would-be users of the database.

4. The Wang et al. (2016) DSD parametrization is used exclusively in the paper's analysis, but as with point 2 above, the justification of its use is simply that it 'was selected' (L151). Why did the authors pick this relatively recent parametrization with few citations? If it were stated that the choice of DSD makes very little difference in a sensitivity test that is not shown, that could be alright. But as it stands this seems to be quite an oversight. Presumably since a small change in large drops could affect bulk scattering properties significantly, it is possible that DSD has a non-negligible effect on the results and conclusions? I don't suggest that the study should turn into a comparison including half a dozen DSDs, but since the conclusions may indeed depend on the DSD chosen this has to be discussed further.

5. This is more minor and just a suggestion, but Fig. 2 and the other plots showing rainfall rate might make more sense with axes flipped. Usually Z-R relationships are shown via such plots, but in your case it is R being varied rather than solving for R. It depends on the focus of course, as Fig. 3 for example makes the point that ZDR is a terrible predictor for R at W-band, but maybe this is worth consideration.

Minor comments:

L33: Might be useful to define spheroid here

L40: This statement is quite vague and would benefit from some references

L67: The use of 'robust' here is questionable. Perhaps 'realistic' or something instead.

L140: There should be units given for quite a few of the variables given in these equations, as N(D) can be per mm or per m, etc. Or at least cite a standard source and say that conventions for units follow those. Also, diameter is typically given as capital D in the radar literature.

L157: 'more illustrative' than what?

L180: 'resistant' is an odd word here. Do you mean that results don't change much based on LOS angle?

L184: 'side LOS angle' was confusing for me, while 'side-looking geometry' used elsewhere was more intuitive

L205: Please say more about how Kdp and rho_hv contain 'information on the shape of the particles.' Also, as is given for Kdp, an example usage of rho_hv would be good for context.

L223: These frequencies aren't given in Table 1. Should we assume the database values were interpolated to these frequencies? And are these analyzed because they are typical microwave link frequencies?

L235: This sentence is quite wordy and could be rewritten to be clearer

L245: In the text it is given as delta TBv - delta TBh, but in Fig. 6 it is TBv - TBh. I understand that it is a blackbody surface assumed so maybe it doesn't matter much, but ensure that this is consistent.

L247: Might be easier to write this out as an equation, to clarify the point above?

L271: There's nothing new in this paragraph and much is restatement of the previous section. Consider trimming or removing this paragraph.

L298: It is great to have some quantitative discussion here, but without reference points it falls flat. Is 1.3K for a 10mm/h rain rate a big error? Some context relative to NEDT or forward model errors could be quite useful, and the same comment applies to values earlier in the section given for radar measurement errors.

L300: This whole paragraph would be better suited in the previous section, as it is more technical than fitting for the summary section.

L306: Please spell out what is meant by 'synergistic' (I'm assuming combined radar/radiometer is what is meant but it's unclear)

L313: It might be good to introduce this concept in the introduction (with references), that something like electric field strength or turbulence can have an impact on orienting drops and their shape as they fall.

L314: This statement is far too vague to conclude the paper. What is meant by 'significant' and are you talking about the SSPs, impact on retrievals, or what? This should be much more specific, and should tie directly to the above on L298, where 'significant' is related to something like sensor noise or other errors. Otherwise there's no way to argue what is 'significant' or not.

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