General comments:

In this manuscript, the authors quantitatively interpret triple-frequency radar signatures in snow and ice clouds observed in Antarctica. Their results indicate that riming starts at lower temperatures in Antarctica than at mid-latitudes and that observed triple-frequency radar signatures with extreme values of DWR_Ka,W (dual-wavelength ratio of Ka and W band reflectivities) can only be explained by approximating the particle size distribution by gamma distributions with high shape parameters mu (called a 'narrow' particle size distribution).

Overall, the manuscript is well written and presents the main points clearly. Nonetheless, some parts of the manuscript could still benefit from more careful editing to improve the grammar and the clarity of the arguments made (the 'Technical corrections' suggested below can provide a starting point).

I think, while some of the points discussed in the manuscript (lengthy discussion of Fig. 4, entire section 4.6, see specific comments below) may add value to the study, they are also difficult to follow and therefore dilute the main results. One important point that could still be discussed in a revised version is how realistic the narrow particle size distributions are that form the basis for the retrieval of ice properties from the triple-frequency radar signatures (see also comment regarding Section 4.4, 4.5 below), given the somewhat extreme values of the PSD shape parameter and the missing information about other commonly used parameters of the size distribution(s).

Considering the high quality of the study and the novelty of the results, I would therefore suggest to publish the manuscript after these points are addressed.

Specific comments:

l. 137 ff: Can the authors quantify these disparities, because these disparities seem to form the motivation for the entire analysis?

For example, a very basic method would be to compare (i) by how much mean or median DWR_Ka,W increases from -25 °C to -15 °C for both locations (also in relation to the width of the distributions with width interpreted e.g. as range from 10th to 90th percentile or standard deviation) and (ii) how much of the DWR_Ka,W distributions is 'much higher than the common maximum of 12 dB'. The general goal here should be to provide some reasonable parameter(s) for how large the disparities are and how (statistically) significant they are for the given datasets. No need for a detailed statistical analysis.

l. 144 ff: Could this low aerosol concentration or a different type of aerosol found over Antarctica not also cause the initiation of aggregation at a lower temperature? What about characteristic differences in the typical wind field, could those affect aggregation/riming temperatures and lead to the initiation of aggregation at a lower temperature in Antarctica? Maybe the authors can present a few (more) arguments to support their conclusion that the differences in observed triple-frequency signatures can only be attributed to the riming process.

Fig. 4 and section 4.2: Sooooo many plots in a single figure. In my opinion, the discussion of this figure also follows many trains of thought that probably all make sense but I could not grasp all of them. To appropriately make all points that the authors intend to make here, more (con)text and multiple separate figures would be needed. I would therefore suggest to focus only on the most relevant points of this entire discussion and omit the rest.

l. 228 ff: I cannot follow this conclusion. Can the authors elaborate a bit or rephrase to clarify?

Section 4.4, 4.5: What range of Lambda values is used for the calculations to obtain the lookup table for the retrievals? Do all the retrieved parameters of the size distributions and the overall ranges used for the retrievals represent realistic size distributions in snow and ice clouds?

For example, Brandes et al. (2007, DOI: 10.1175/JAM2489.1) rarely observed Gamma-PSD shape parameters of mu > 10 in their in situ observations at mid-latitudes. Gergely (2019, DOI: 10.1016/j.jqsrt.2019.106605) found a strong impact of the maximum snowflake diameter of the chosen particle size distribution on radar retrievals. Other studies also suggest that the slope parameter Lambda spans only a somewhat limited range of values. How do the values that the authors use and the ones they ultimately retrieve compare to those discussed in other studies? Are they similar? Or is there any reason why a different range of values may be appropriate to describe particle size distributions in Antarctica?

Maybe the authors could also plot some of the size distributions that they retrieve or just some generic Gamma-PSDs to illustrate what a 'narrow' size distribution looks like vs. a 'wide' size distribution, as understood by the authors in the context of this study (confusion can arise here because the parameter Lambda can also be interpreted as a measure of the width of the distribution).

l. 350 and following paragraphs: Substitute 'measurement uncertainties' and 'retrieval uncertainties', etc. for 'errors'. These are uncertainties, not errors.

Section 4.6: While this section describes an interesting exercise, it is not entirely clear to me whether this chapter adds anything substantial to this study, particularly because the results are mostly qualitative and can be interpreted as a type of consistency check. In my opinion, this does not add a lot of signifant results to the results presented in the previous chapter(s). I would instead (or additionally) prefer to see a brief discussion on how realistic the 'narrow' particle size distributions are, e.g., based on a comparison/discussion of studies that have used and obtained relevant parameters of snow and ice particle size distributions from in situ observations (see also comment regarding Section 4.4, 4.5).

Technical corrections:

l. 69: 'data' instead of 'Data'?

l. 144: 'this difference' or 'these differences', but not 'this differences'

Fig. 2 caption: 'temperature profiles'

l. 188: Do you mean ... 'refractive index' ...

l. 193: I do not understand ' where the temperature is comprised between -25 and -40_C', please rephrase, maybe you mean 'where the temperature is between -25 and -40 °C'.

l. 212 ff: Can you rewrite this discussion, so it is more easily understood. For example, I get confused by multiple clauses starting with 'conversely' so close to each other.

l. 214: Do you mean ... vertical 'bands' ... that alternate between blue and red?

l. 224: spectrum width (singular)

l. 226: Well, apparently they are not identical. Why not use ‘very similar’ or something along those lines?

Fig. 7 caption: replace ‘comprised between’ with ‘of’

l. 388: delete ‘notable’

l. 394: Likewise, Fig. 9 c ... (instead of ‘Likewise, the figure 9 c’)

l. 421: What does ‘liquid-free layer’ mean? Without liquid water present?

l. 424: What is a ‘geometrically-thick liquid water hydrometeor population’. Can you rephrase this to make it clearer?

l. 508: maybe better to write something like ‘These similarities are also evident from Fig. 11a which shows the spread ...’

l. 545: ... allows us to constrain the microphysical properties of the ice particles ...