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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Linkage among Ice Crystal Microphysics, Mesoscale Dynamics and Cloud and Precipitation Structures Revealed by Collocated Microwave Radiometer and Multi-frequency Radar Observations" *by* Jie Gong et al.

Jie Gong et al.

jie.gong@nasa.gov

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We highly appreciate Dr. Matsui's in-depth review and constructive suggestions. The English/grammar errors pointed by this and other reviewers have been corrected. The revised draft has been carefully proofread by the 4th author, who is a native speaker. The missing colorbars have now been added back. Below are point-by-point responses (in blue).

Life cycle vs. cloud structure: Line 218: can you weaken the word "conclude"? Actually, without tracking actual life cycle of deep convection, you cannot conclude your hypothesis. This could be explained by the location of cell (how close to the convective cores or geographic locations) in addition to the life cycle as seen in Fig 9. If you can, plot classification of categories 1-4 on Fig 8 case (like several case in horizontal map)? You may see all categories in one case of MCSs regardless of the life cycle of MCSs.

We totally agree with the reviewer that sometimes the tone was too strong, and indeed we cannot make a concrete conclusion without observing the entire life cycle of many convective systems, which is only possible on a geostationary platform from spaceborne point of view. Here at Line 218, we've replaced "conclude" with "summarize". We also add one more sentence reads as "Without actually tracking the entire life cycle of convective system(s), these arguments are just speculations. We will show some supportive evidences in Section 5 using an ensemble of squall lines. Furthermore, at this point, we cannot yet determine whether…".

GPM DPR-CloudSat CPR mismatch: Line 353: You stated that you cannot trust Figure 7d due to imperfect match for microphysics analysis. In that case, you cannot also trust neither Ka/W nor Ku/W analysis in Figure 6? Can you justify why one analysis is trustable (Figure 6) and other (Figure 7d) is not. Since Ku/Ka is perfectly matched, but Ku/W and Ka/W are not, we can in principle compare $DFR_{Ku/Ka}$ directly with theoretical calculations as long as we believe the theoretical calculation is correct, but only compare $DFR_{Ku/W}$ and $DFR_{Ka/W}$ qualitatively with theoretical calculations. Comparing Fig. 6 with Fig. 7, the main features in Fig. 6a and 6b agree with each other, so although both of them have caveats, we choose to keep them as they are telling consistent stories. For Fig. 7, since some features in the left do not match those in the right panels, we choose to interpret results to the left because they are from perfect matches, while leaving the right panels as "less trustworthy". The tone has been re-tuned to clarify our points.

Technical Corrections

Line 38: “how much of that precipitation reaches the ground and where” -> “how much and where precipitation reaches the ground”

Corrected. Thanks.

Line 50: Add citations of triple-frequency radar retrievals.

Chase et al. [2018, GRL] has been added, which demonstrates the capability of revealing ample frozen particle characteristics using the triple-frequency radar retrievals. In addition, the 5 citations included in the line above are also related to triple-frequency radar retrievals, so they are not replicated again here.

Line 70: Remove “healthy”

Removed. Thanks.

Line 78: Computational cost is not the answer of using spherical assumption. It is just uncertain to derive size and orientation simultaneously.

Thanks for the suggestion. Now the sentence has been altered as “random orientation is still nearly always assumed to avoid the complexity of deriving size and orientation simultaneously, as well as to avoid solving equations for 4 Stokes parameters simultaneously”.

Line 90: Please add citations of Olson et al. 2001 with several sentences in the introduction. This is probably most related original paper of using PD to discuss oriented non-spherical ice in the stratiform precipitation.

A sentence has been added to Line 93-94, which reads as “In particular, Olson et al. [2011] used TMI 89 GHz PD as one of the several parameters for stratiform/convective precipitation classification.” This paper is also discussed later (Section 5, around Line 451-453).

Line 114: “Microwave Imager” -> “GPM Microwave Imager”

Added. Thanks.

Line 118: “250m” -> “500m” range resolution of interlaced DPR Ka band is 500m.

I checked the ATBD of DPR Level 2 retrieval products, and I believe the vertical resolution is 250m.

Line 121: “correction” -> “attenuation correction”

Added. Thanks.

Line 148: Remove “(rain or ice)”.

Removed. Thanks.

Line 157: Please write the resolution of ECMWF analysis.

After checking the ATBD of ECMWF-AUX dataset, we realized they used 0.5-deg 3-hourly forecast data for interpolation to CloudSat orbit time and location. The text has been updated and the new citation “Cronk and Partain, 2017” has been updated to replace the P04 ATBD.

Line 180: “convective scenes” -> “convective core”.

Change made. Thanks.

Figure 2: Shade bar and values in contour lines are missing.

Colorbar added now. Thank you.

Line 207: “less and less” -> “lesser”

Corrected. Thanks.

Line 208: “more and more thick” -> “thicker”

Corrected. Thanks.

Line 215: “the melting layer” -> “the melting layer due to increased temperature”

Added. Thanks.

Line 270: "presented evidences" is too strong. Suggest "Our analysis in Section 3 supports that. . ..". Everything from remote sensing of microphysics is retrieval and guess. Without direct measurement of in-situ observation, you cannot conclude it.

Thank you. Change made and toned down.

Figure 6: Again, color shade bars and values in contours are missing.

Colorbar added now. Thank you.

Line 305: I'm not sure about these isolated sample. How significant it is. Can you still say the sample close to theoretical curve? It does not look like.

Out of the 704 "low-PD" samples between 5.5 – 15 km height range, 128 of them fall into the range to make the color shaded contours in Fig. 6a and 6b. While 89 of them make the low DFR blob, the rest 39 samples make the large $DFR_{ka/w}$ and small $DFR_{ku/ka}$ blob to the right, so they are not from isolated samples. The difficulty we face here is that the theoretical curve can only account for a small portion of variability that we observed from collocated CloudSat-DPR, but the latter group of 39 samples are closer to the heavily rimed particle calculation.

Line 359: How do you roughly define "large" or "small" ice particle here? What is the size ranges of ice particle?

We admit that "large" and "small" are relative to each other, and we don't have a clear size range for each of them. Here "small" means cloud ice particles that have negligible fall speed, while "large" particles are precipitation-sized ones that have a non-trivial fall speed. They roughly separate at $\sim 100\ \mu m$ mass weighted effective radius.

Line 439: "enjoy"?

We do feel it is appropriate to use a metaphor here, so no change is made.

Line 447-449: If you like to conclude this, you must show the plot using 89GHz (e.g., in Appendix). Otherwise, you cannot state it.

We included "(Fig. A2 in the Appendix)" in the parentheses now. Thanks.

Line 451: "highest frequency dual-polarized radiance measurements" -> "highest frequency of dual-polarized microwave radiance measurements"

Suggestion incorporated. Thanks.

Line 475: You must also mention to use ground-based polarimetric radar for alternative approach, too.

Sorry that we are not quite sure how ground-based polarimetric radar can help delineate the intertwined size/orientation/size/riming microphysical properties. Would you please suggest some references? Based on my standing, if it's single frequency polarimetric radar, it can tell more information about density and fall speed, but not very helpful on retrieving other parameters.

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