This paper presents analysis of EarthCARE Doppler velocity measurements that coincide with identified tropical cyclones. It combines EarthCARE measurements and a tropical cyclone tracking dataset to evaluate dynamical and microphysical properties of tropical cyclones.

Considering the novelty of this type of data, I think this work has the potential to be impactful. The paper would benefit from reframing of the problem and clearer presentation of data to support the conclusions being made. My main suggestion is to highlight the parts of the study that are novel. For example, the abstract states that the results show a transition from a convective-like structure in the eyewall to a stratiform structure in the rain band. While it is useful to confirm that the orthodox picture of tropical cyclones holds when evaluating it against global Doppler velocity retrievals, the strength of the dataset is that new or uncertain relationships can be evaluated. Moreover, the main value of the data is that it provides global measurements of the "coupling between dynamics and cloud microphysics in TCs", but the conclusions made about the coupling are presented with either weak or unclear evidence. In the following review, I point out places where I suggest the paper should be reframed and strengthened.

We thank the reviewer for this overall assessment and helpful suggestion. In the revised manuscript, we have reframed the main observational findings to emphasize the regional differences in Doppler velocity distributions and their relationships with vertical air motion and particle sedimentation, rather than focusing primarily on the convective-to-stratiform transition. We have also strengthened the supporting analyses and clarified the interpretation of the coupling between dynamics and cloud microphysics. Detailed revisions addressing these points are described in our responses to the specific comments below.

- L47: How do you know that "the presence of supercooled liquid water has important implications for latent heat release in the upper levels."? The latent heat of freezing is an order of magnitude smaller than the latent heat of condensation/deposition, so there would need to be significantly more supercooled water freezing than other types of latent heat release for it to contribute a lot to TCs.

We agree with the reviewer that the original statement overemphasized the direct contribution of freezing latent heat. We have therefore revised as the follows: 'The presence of supercooled liquid water affects riming, freezing, and hydrometeor growth in the upper levels' in Line 48-49.

- Lines 46-56 summarize an open problem in the field that I think this paper may address. The summary states that there has been some prior work examining how supercooled water in the upper parts of the tropical cyclone impacts TC intensity, but there is disagreement about whether or not supercooled water exists in large quantities there. It seems to me that the EarthCARE data presented in this work can both evaluate whether the supercooled water exists in large quantities (compared to other condensate) and whether the presence of supercooled water impacts the intensity of the TC. (Whether it impacts the vertical velocity or maximum radial wind.)

We thank the reviewer for this insightful suggestion. We agree that the occurrence of supercooled and mixed-phase particles is an important open question that EarthCARE can help address. However, the AC_CLP particle classification used in this study identifies particle types rather than directly quantifying the mass of supercooled liquid water. We have therefore revised the manuscript to make this limitation explicit. In the revised Introduction and Results, we focus on the occurrence and vertical distribution of mixed-phase and supercooled particle classifications and their relationship with Doppler velocity and vertical air motion, rather than making quantitative claims about the amount of supercooled water or its direct impact on TC intensity.

- Fig. 2: I'm unclear on how these figures are generated. Do you collocate the TC, then take the average radar reflectivity given by EarthCARE over the portion of the TC that EarthCARE crosses? Then bin the resulting 1D profile by the RMW of the TC? If that is indeed the methodology, then how do you deal with the following two cases: (1) the EarthCARE satellite passes 900 km away from an RMW=10 tropical cyclone, in an area where there is just stratiform precipitation and (2) the satellite passes through the center of an RMW=10 tropical cyclone? In Fig. 2b, would these two profiles get averaged together? The method you use should be clearly presented in the paper.

We thank the reviewer for pointing out that the construction of the radial composites was not sufficiently clear in the original manuscript. We have expanded Section 2.2.1 to describe the procedure explicitly. For each EarthCARE radar profile, we calculate the distance from the interpolated TC center at the overpass time and normalize that distance by the corresponding RMW. All valid profiles are then grouped according to their normalized radial distance and composited within each radial bin.

Therefore, profiles are not averaged simply because they belong to the same TC intercept. For example, a profile sampled far from the storm center is assigned to a large normalized-radius bin, whereas a profile passing through the inner-core region is assigned to a small normalized radius bin. Only profiles falling within the same normalized radial bin contribute to the same composite value. Because sampling is limited near the TC center, all profiles within 2 RMW are combined into a single inner-core bin, while 1-RMW bins are used from 2 to 15 RMW. We have also added supplementary sampling information showing both the number of independent intercept events and the number of valid profiles contributing to each radial bin.

- The second sentence in Section 3.1 states that sufficient number of samples exist for RMW ranging from 2 to RMW. The next sentence then draws a conclusion about RMW<2. Since the number of samples is low there, it is unreasonable to draw conclusions about those results.

We agree with the reviewer that the limited number of independent samples in the inner-core region requires caution. We have revised the manuscript to explicitly state that only two independent EarthCARE intercept events contribute to the inner-core composite. To assess the robustness of these results, we additionally compare the individual-event vertical profiles in the Supplement. Although the two cases show similar vertical structures in Doppler and air velocities, we emphasize that these results should not be interpreted as statistically representative of TCs in general.

- I don't see why this is true: "A relative minimum in reflectivity at 5 RMW suggests a separation between the primary and outer rainband regions." What other evidence do you have, or prior work, shows this?

We agree that the original interpretation of the reflectivity minimum near 5 RMW was not sufficiently supported. We have removed this statement and no longer interpret 5 RMW as a physically defined boundary between the primary and outer rainbands. Instead, 5 RMW is used as a practical threshold for the regional analysis. We also performed sensitivity tests using 4 and 6 RMW as alternative boundaries, and the resulting Doppler velocity distributions remain qualitatively similar (see Fig. S4 and S5 below).

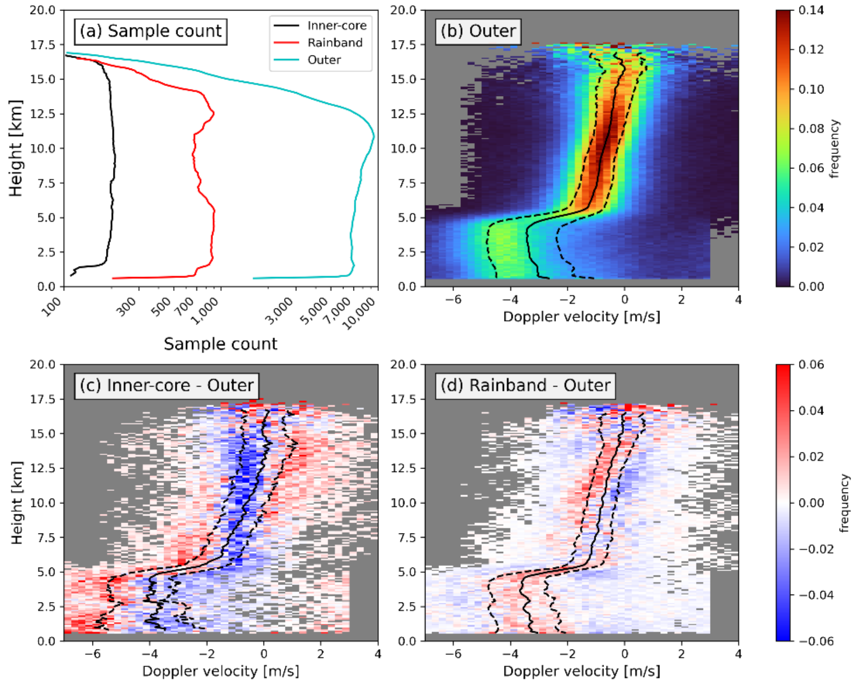


Figure S4. Same as Fig. 3, but using 4 RMW as the boundary between the rainband and outer regions. The rainband and outer regions are therefore defined as 2–4 RMW and 4–15 RMW, respectively.

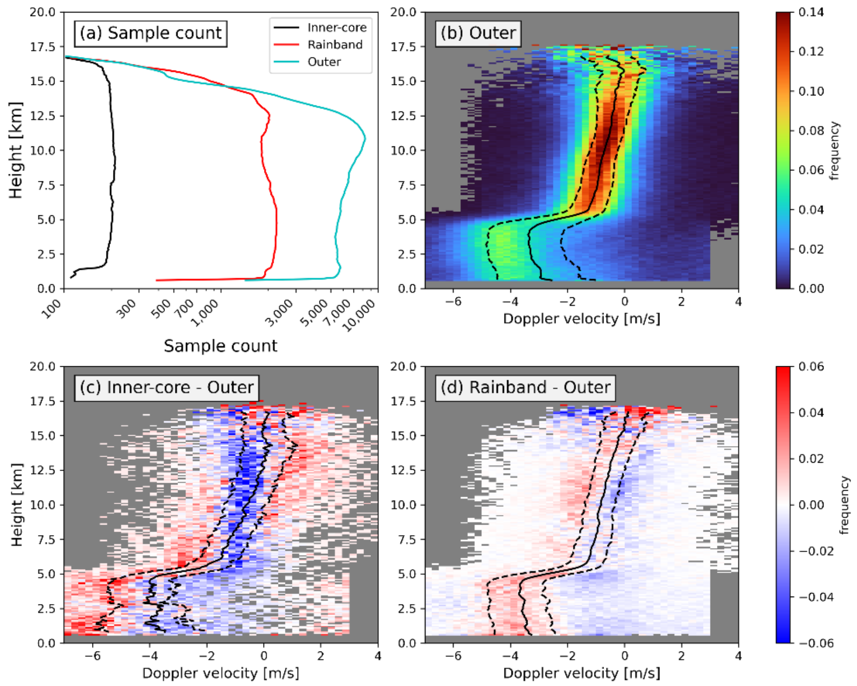


Figure S5. Same as Fig. 3, but using 6 RMW as the boundary between the rainband and outer regions. The rainband and outer regions are therefore defined as 2–6 RMW and 6–15 RMW, respectively.

- It looks like air velocity is positive everywhere in the tropical cyclones that you observe, according to Fig. 2b. Is that what you expect? Why is that?

We thank the reviewer for raising this point. The positive mean air velocity should not be interpreted as the mean vertical motion over the entire TC circulation. Our analysis is conditional on radar-detectable cloud and precipitation samples because only grid points with radar reflectivity greater than −20 dBZ are retained. Therefore, the composite preferentially samples cloudy regions, where upward motion is more frequently observed. This sampling criterion is described in Section 2.2.1.

- Fig. 3 b-d. Is the probability distribution normalized by each row, or is this a two-dimensional histogram? Should we interpret these figures as the probability density of the doppler velocity at 5 km, for example? Moreover, when you write Eyewall-Outer and rainband-Outer, do you mean that you compute the PDFs of each, then subtract the PDFs?

We thank the reviewer for pointing out that. We have clarified the procedure in Section 3.2: 'At each height, the Doppler velocity PDF is normalized independently using the valid samples at that level, so that each vertical level represents its own Doppler velocity distribution.' in Line 274-275. Thus, for example, a horizontal slice at 5 km represents the Doppler velocity probability distribution at 5 km. For Fig. 3c and 3d, we first calculate the normalized PDF separately for each radial region and then subtract the outer-region PDF from the inner-core or rainband PDF, respectively. Positive values therefore indicate Doppler velocity ranges that occur more frequently than in the outer region, while negative values indicate lower relative frequency.

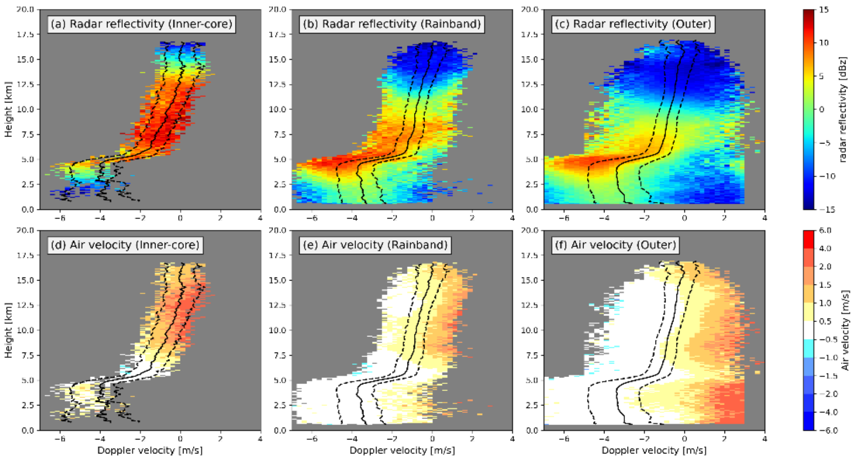
- "Above 6 km, enhanced reflectivity is generally associated with Doppler velocities below the upper quartile, suggesting that Doppler velocity in the rainband is contributed by the particle falling" Isn't Doppler velocity always impacted by falling hydrometeors? What is this statement attempting to distinguish about the rainband?

We agree with the reviewer that hydrometeor fall speed always contributes to Doppler velocity, and the original wording did not clearly describe what distinguishes the rainband region. We have therefore revised this discussion. The revised analysis shows that vertical air velocities in the rainband and outer regions are broadly similar over much of the ice-phase layer, whereas the radar reflectivity-weighted terminal velocity and retrieved particle terminal velocity are slightly more negative in the rainband. We therefore interpret the systematic negative shift of the rainband Doppler velocity distribution relative to the outer region as being more closely associated with differences in particle sedimentation rather than vertical air motion.

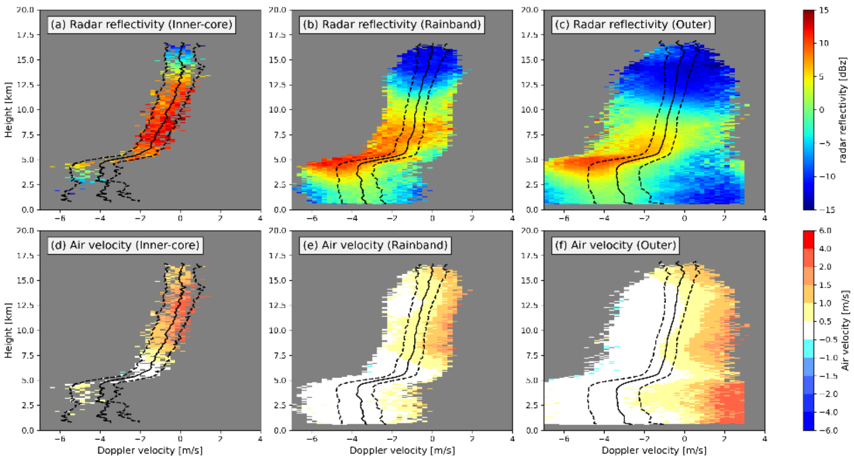
- "We eliminate the points where sample size less than 5." That's a very low threshold. How does increasing this impact the results?

We thank the reviewer for raising this concern. The minimum sample threshold in Fig. 4 is used only to mask poorly sampled Doppler velocity–height bins and does not affect the calculation of the conditional composites themselves. We repeated the masking using thresholds of 10 and 15 samples (see figures below). Although the displayed area becomes smaller as the threshold increases, the main patterns and regional differences remain qualitatively unchanged.

The same figure as Fig. 4, but the region where sample size is less than 10 is masked.



The same figure as Fig. 4, but the region where sample size is less than 15 is masked.



- Fig. 6. It may be worth emphasizing that this probability density plot differs from the other types of probability density plots you showed. It looks like the probability is normalized by column here, which is not the case for the others (like 3 or 7). Are we to interpret each column as the probability density of (in (a), for example) small ice particles occurring at each height, binned by the RMW? This plot is also missing labels on the x axis and color bar.

We thank the reviewer for pointing out that the normalization of Fig. 6 was unclear. We have clarified the calculation in the revised manuscript: 'At each radial-distance-height bin, particle frequency is calculated as the number of samples classified into each particle group divided by the total number of valid particle classifications in that bin. Therefore, the frequencies of the five groups sum to one in each bin'. This normalization is different from the Doppler velocity PDFs shown in Fig. 3 and 7. We have also revised Fig. 6 to include the missing axis and color-bar labels.

- Why not plot Fig. 7 with air velocity instead of Doppler velocity on the x axis? It seems to me that you are aiming to relate condensate and air motion in the text, so the figure might support your conclusions better if it used air velocity.

We thank the reviewer for this suggestion. We agree that relating particle type directly to air velocity would be useful for examining cloud dynamics. However, we retain Doppler velocity on the horizontal axis because it is directly observed by CPR, whereas air velocity is a retrieved quantity obtained by estimating and removing the hydrometeor terminal velocity from the Doppler measurement. The uncertainty in retrieved air velocity is therefore larger and depends on assumptions about particle properties and terminal velocity, particularly in mixed-phase regions. For this reason, we use the more directly observed Doppler velocity in Fig. 7 to examine how different particle types occupy different parts of the measured velocity distribution. The relationship with air motion is then interpreted using the retrieved air velocity analyses in Figs. 4 and 5.

- "In particular, the occurrence of supercooled water and mixed-phase particles in regions of upward motion implies that riming processes are likely enhanced within convective updrafts, where supercooled liquid water is available." This sentence is stated in reference to Fig. 7, which combines all the data, whether it was taken at the eyewall or rainband. Since that's the case, it is unreasonable to make conclusions specifically about convective updrafts based on this figure. Is it possible to subset to only the convective part of the storms to evaluate your hypothesis? Is it possible to show that riming is more important than other condensate formation processes?

We agree with the reviewer that the original interpretation was too strong. Because Fig. 7 combines samples from all radial regions, it does not provide sufficient evidence to attribute the observed mixed-phase particles specifically to convective updrafts. In addition, the available observations do not allow us to isolate riming from other condensate growth processes. We have therefore removed these statements and revised both figure and description. The revised discussion is limited to the observed relationship between particle type and Doppler velocity. The paragraph is revised as the follow: 'We further project the frequency diagrams onto Doppler velocity PDFs to investigate the relationship between Doppler velocity and cloud particle types. Because the sample sizes in the inner-core and rainband regions are insufficient for constructing separate frequency diagrams, all three regions are combined to construct the frequency diagrams in Doppler velocity space (Fig. 7). Small ice particles dominate above 7.5 km, except in regions beyond the upper quartile of Doppler velocity (Fig. 7a). In these regions, snow particles are present, although with lower frequency (Fig. 7b). Snow particles are mainly found between approximately 5 and 12 km and extend toward more negative Doppler velocities than small ice particles (Fig. 7b). Below the freezing level, rain is the dominant particle type (Fig. 7c). However, its frequency decreases in the region of Doppler velocity close to 0 m s-1, where small liquid droplets become more evident (Fig. 7d). Mixed-phase particles are concentrated near and above the melting level and exhibit a distribution across a broad range of Doppler velocities (Fig. 7e). Enhanced frequencies occur on both the more negative and less negative (or near-zero) sides of the Doppler velocity distribution. The less negative side overlaps with Doppler velocity ranges where stronger upward air motion is identified in Fig. 4, while the more negative side is consistent with faster particle falling. These results indicate that mixed-phase particles occur under two different conditions: convective-like vertical air motion and regions with faster ice particle falling. The different cloud particle types occupy distinct parts of the Doppler velocity distribution, which provides the relationship between cloud particle properties, vertical air motion, and particle falling motion in TCs for evaluating cloud microphysics in models.'

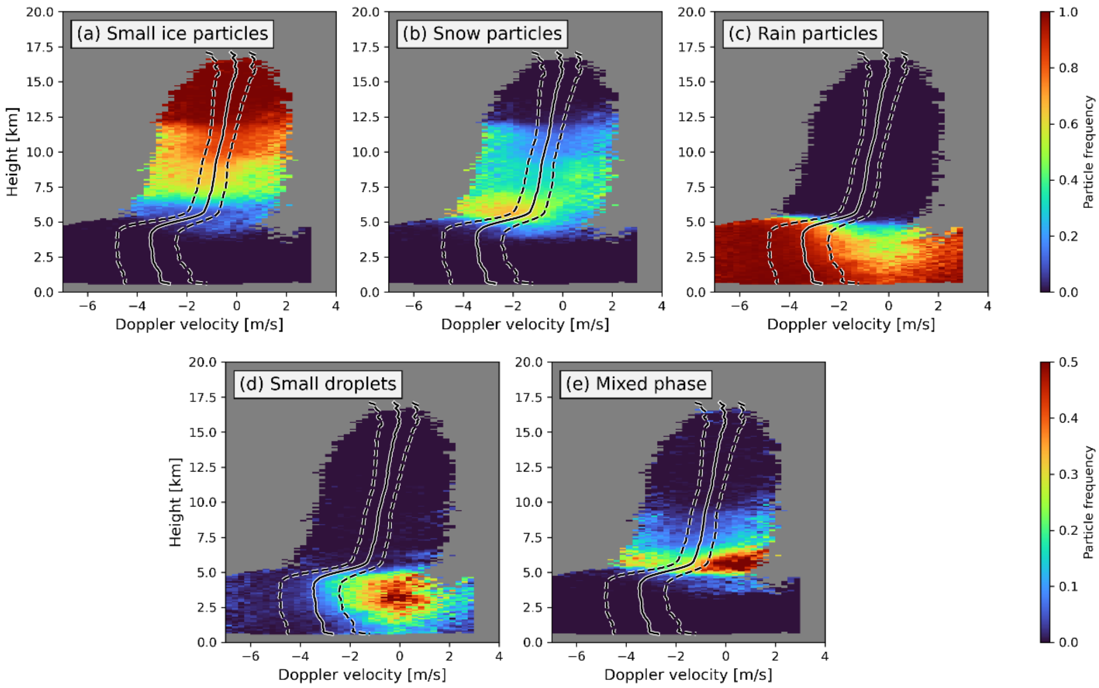


Figure 7. Frequency diagrams of (a) small ice particles, (b) snow particles, (c) rain particles, (d) small droplets, (e) mixed-phase particles on the DPF of Doppler velocity.

- Fig. 7d shows the two-dimensional histogram of supercooled water. It looks like supercooled water is most prevalent when the dopper velocity is highest. The claim that supercooled water is more prevalent than expected would be stronger if there was a clearer comparison of the relative frequencies of the different type of particles.

We thank the reviewer for this suggestion. We agree that examining a single supercooled-water distribution alone does not provide a sufficient basis for assessing whether it occurs more frequently than other particle types. We have therefore reorganized the particle-type analysis to provide a clearer comparison of relative frequencies. In the revised Fig. 6, the retrieved particle classifications are grouped into five categories: small ice particles, snow particles, rain particles, small droplets, and mixed-phase particles. This provides a direct comparison of the relative occurrence of the different particle groups. We have also revised Fig. 7 using these grouped categories and reduced the emphasis on supercooled water alone. Accordingly, we no longer make a strong quantitative claim that supercooled water is more prevalent than previously expected.

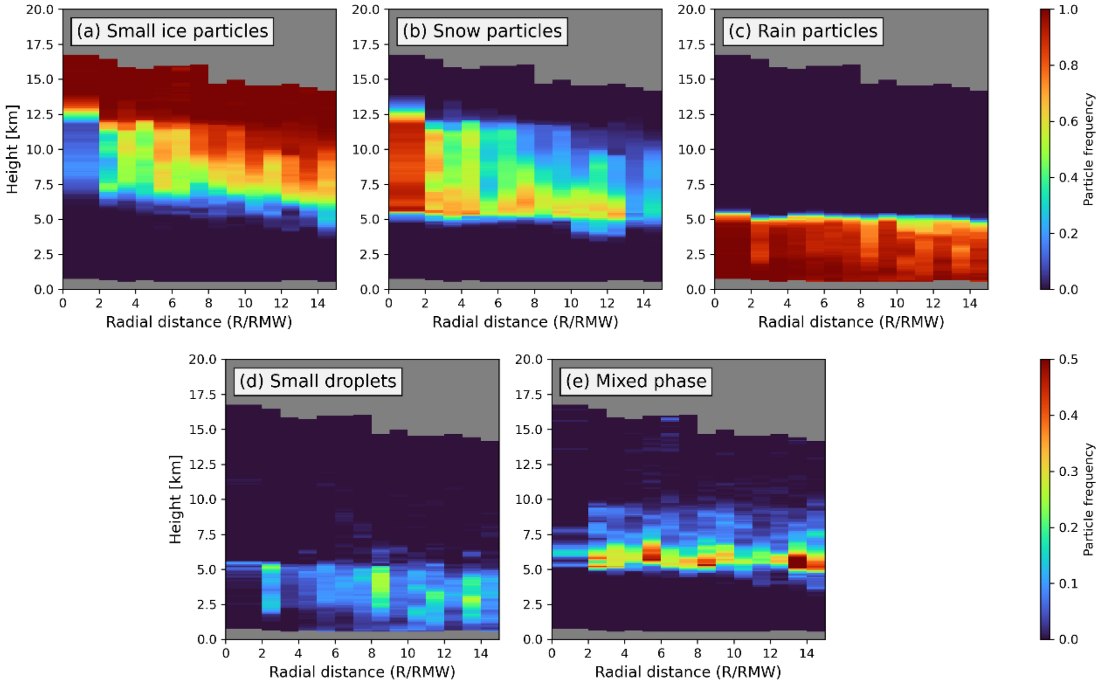


Figure 6. RMW-height frequency diagram of (a) small ice particles, (b) snow particles, (c) rain particles, (d) small droplets, and (e) mixed-phase particles.

Minor comments

- Typo in affiliation 1: Atmoshpere -> Atmosphere

We thank the reviewer for pointing out this typo. It has been corrected.

- Typo in correspondence name: Hunag -> Huang

We thank the reviewer for pointing out this typo. It has been corrected.

- L42: This sentence is unclear, should rephrase: "The above studies demonstrated a breakthrough in TC understanding using CloudSat observations despite only radar reflectivity"

We agree that the original sentence was unclear. We have revised it to: ‘These studies demonstrate the value of CloudSat radar observations for understanding TCs, although CloudSat provides radar reflectivity without Doppler velocity.’

- L48: Should be past tense, and phrasing is unclear: "Therefore, supercooled water is regarded as the target to weaken TC structure and intensity by seeding during STORMFURY (Willoughby et al., 1985)." Is this saying that the goal of the campaign was to reduce the amount of supercooled water in storms?

We thank the reviewer for pointing out the unclear wording. We have revised the sentence to use the past tense and to describe the purpose of Project STORMFURY. The revised text now states: ‘Project STORMFURY therefore attempted to modify TC structure and intensity by seeding supercooled water (Willoughby et al., 1985).’

- I suggest editing the text for clarity.

We thank the reviewer for this suggestion. We have carefully revised the manuscript throughout to improve clarity

- Fig 2a: The color bar chosen here makes it hard to distinguish small and large values.

We thank the reviewer for this suggestion. We have revised Fig. 2a to improve the visibility of the sample-size distribution. The figure now displays the actual sample counts to make it easy to be distinguished.

- Fig 7: hard to see the black line on dark blue background

We thank the reviewer for pointing this out. We have revised Fig. 7 to improve the contrast and visibility of the overlaid lines against the shaded frequency distribution.

- Fig. 10, 11: hard to see the tick labels

We thank the reviewer for this comment. We have revised Figs. 10 and 11 by increasing the size and improving the visibility of the axis tick labels and other figure annotations.

- How many samples are there? How many TCs did EarthCARE intercept over the 14 month period?

We thank the reviewer for pointing out the need to report the sampling information more clearly. The revised manuscript now states ‘Radial composites are constructed by collecting all valid EarthCARE profiles within each normalized radial bin. The dataset includes 101 EarthCARE intercept events from 28 TCs in the Northern Hemisphere. These intercepts provide 1,853 valid profiles within 15 RMW.’ in Line 155-157.