Review of "EarthCare Observations of Vertical Motion and Cloud Microphysical Structure in Tropical Cyclones"

Overall Assessment

This is a good and interesting manuscript that makes use of a novel observational dataset to characterize vertical motion and cloud microphysical structure in tropical cyclones. That said, I feel the analysis stops somewhat short of its potential, and a deeper treatment of several points below would substantially strengthen the paper's contribution.

Major Comments

1. **Model improvement pathway needs to be made concrete.** The most compelling potential contribution of EarthCARE observations is their ability to improve model representations of TC processes, but this is not developed. For instance, on Line 433 the authors state that "the observational constraints offer guidance for improving the representation of cloud microphysical processes in models," but no specifics are given. I would strongly encourage the authors to elaborate on this point — what specific microphysical parameterizations or processes could be constrained, and how would one go about using these observations to do so? Even a focused discussion of one or two concrete examples would considerably strengthen the paper.

   We thank the reviewer for this helpful suggestion. We agree that the model-improvement pathway should be described more concretely. We have therefore added a discussion at the end of the manuscript describing how different retrieved quantities can be used to constrain specific aspects of cloud microphysics. The added discussion can be found in Line 574-582: 'EarthCARE provides complementary constraints for model development. Radar reflectivity is sensitive to particle size distributions, while cloud water and ice contents provide information on condensate mass. Comparing Doppler velocity with retrieved air velocity can further help evaluate particle sedimentation and terminal-velocity settings. Although these retrieved quantities are not fully independent because they share radar inputs and retrieval assumptions, their combined evaluation can help identify microphysical settings that improve the representation of both particle distributions and sedimentation. This study compares two commonly used configurations within the single-moment NSW6 scheme to isolate the sensitivity to their different falling speed assumptions. Future studies will examine the terminal velocities of individual hydrometeor species, compare NSW6 with the double-

moment NDW6 scheme, and evaluate the sensitivity of simulated vertical motions to model resolution'.

2. **Justification for single-moment microphysics.** Why was a double-moment scheme not tested? NICAM does have a double-moment microphysics option available (see Seiki and Nakajima, 2014, J. Atmos. Sci., 71, 833–853, who developed the NDW6 double-moment scheme). The authors should clarify why they chose to test only a single-moment scheme — even if they also ran a sensitivity test with modified parameters — or, if feasible, discuss how the results might be expected to differ under a double-moment or even bin microphysics representation.

   We thank the reviewer for this important comment. In this study, we intentionally focus on the single-moment NSW6 scheme because our primary objective is to evaluate the scheme with two common configurations. The K21 and T24 configurations are both commonly used NSW6 settings in recent NICAM applications, providing a practical basis for comparison within the NICAM community. We agree that the double-moment NDW6 scheme is an important option for future evaluation. However, double-moment NDW6 scheme would add additional degrees of freedom, which would make it difficult to discuss effects of terminal velocity. We therefore leave a direct comparison between NSW6 and NDW6 to future work and have added this point to the revised manuscript in Line 580-582: 'Future studies will examine the terminal velocities of individual hydrometeor species, compare NSW6 with the double-moment NDW6 scheme, and evaluate the sensitivity of simulated vertical motions to model resolution.'.

3. **Imprecise language in places.** For example, on Line 418 the text states "with a long tail extending toward 1 g/m³ (Fig. 11a)," but the figure appears to show the distribution extending beyond 1 g/m³. Please review the manuscript for similar instances where the wording does not accurately match what is shown in the figures.

   We thank the reviewer for pointing this out. We have revised the description of Fig. 11 so that the stated ranges more accurately match the distributions shown in the figure. We also reviewed and revised imprecise descriptions where necessary throughout the manuscript.

4. **Sample size should be reported.** How many individual tropical cyclones were sampled in this study? This is arguably more important for assessing the robustness and generality of the results than the time period of the dataset, which is currently the only sampling information provided.

We thank the reviewer for this suggestion. We have added detailed sampling information to the revised manuscript in Line 155-162: 'The dataset includes 101 EarthCARE intercept events from 28 TCs in the Northern Hemisphere. These intercepts provide 1,853 valid profiles within 15 RMW. Because the number of satellite intercepts differs substantially with radius, we examine both the number of independent intercept events and the number of valid profiles contributing to each radial bin (Fig. S2). Because the number of EarthCARE samples decreases substantially toward the TC center, all profiles within 2 RMW are combined into one radial bin, whereas 1-RMW bins are used from 2 to 15 RMW in the subsequent analyses. Sampling is particularly limited within 2 RMW, so individual-event mean vertical profiles are compared to assess the robustness of the inner-core statistics (Fig. S3)'. We have also added a supplementary figure showing both the number of independent intercept events and the number of valid profiles contributing to each radial bin (see Fig. S2 below). Because sampling is particularly limited in the inner-core region, we further compare the individual-event vertical profiles in the Supplement to assess the robustness of the composite results (see Fig. S3 below).

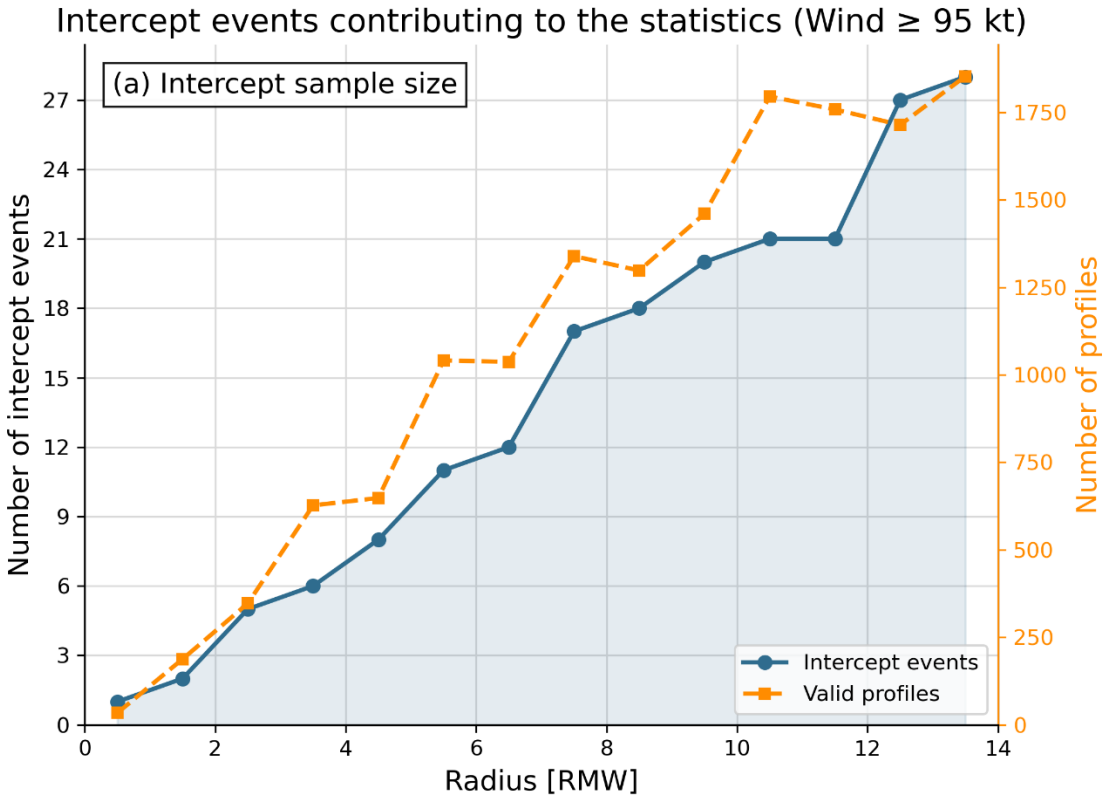

Figure S2. Number of independent EarthCARE intercept events (blue) and valid profiles (orange) contributing to each normalized radial bin for Category 3 and stronger TCs.

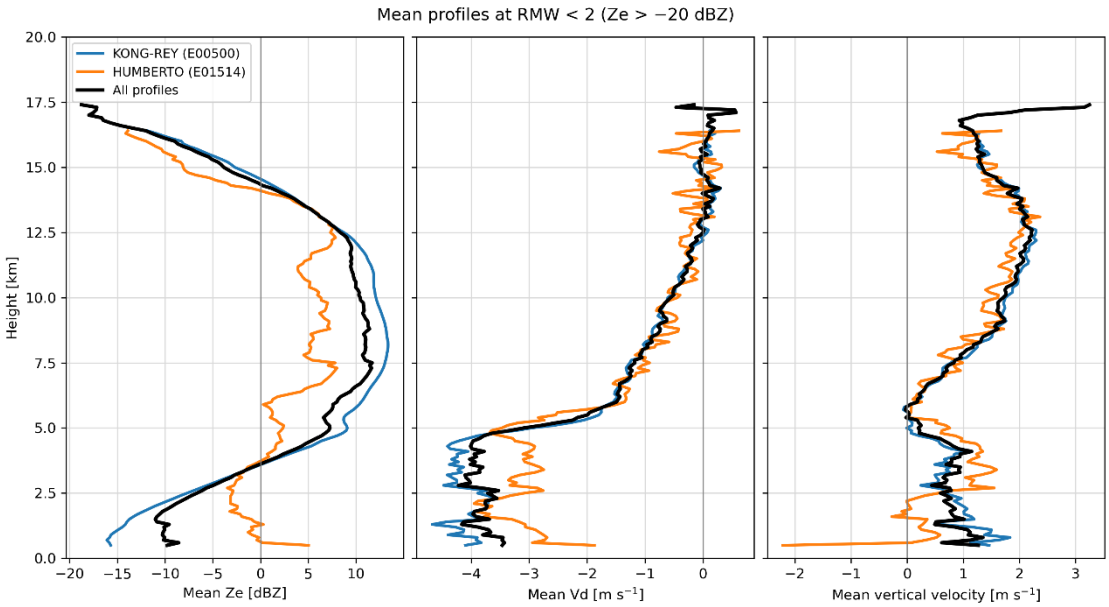

Figure S3. Mean vertical profiles of radar reflectivity (left), Doppler velocity (middle), and vertical air velocity (right) for the two independent EarthCARE intercept events contributing to the inner-core region (R < 2 RMW). The black lines show the profiles calculated using all inner-core samples.

Specific/Editorial Comments

- **L40:** "suggesting that rapid intensification may be a precursor to TC intensification" — this phrasing is circular/redundant and should be rephrased.

  We thank the reviewer for pointing this out. We have revised the sentence to: 'Wu et al. (2020) then showed that the intensification rate is correlated with IWC in rapidly intensifying TCs, suggesting that enhanced IWC may be a precursor to rapid intensification.' in Line 41-42.

- **L63:** Is TC rapid intensification really absent in coarser-resolution models? Please provide a citation to support this statement.

  We agree that the original statement was too strong. We have revised the sentence to avoid implying that rapid intensification is entirely absent in coarser-resolution models: 'Baker et al. (2024) further demonstrated that GSRMs can simulate rapid intensification, which is hard to be represented in low-resolution conventional global climate models.' in Line 65-66.

- **L68:** "in Roh et al. (2026) they argued" should be revised to "Row et al. (2026) also argued."

  We thank the reviewer for the correction. We have revised the citation as Roh et al. (2025).

- **L210:** "Between 5–10 km, a mixture of ice and liquid phases exists"

  We thank the reviewer for this suggestion. During revision, we reconsidered this interpretation and removed the statement from this section.

- **L254:** "by particles falling" should replace "the particle falling."

  We have revised this part of the manuscript and no longer use the original wording.

- **L455:** "although uncertainties remain in the retrieval" — can the authors quantify these uncertainties, even approximately?

  We thank the reviewer for raising this point. Quantifying the retrieval uncertainty with a single representative value is difficult because the uncertainty depends strongly on cloud regime, particle properties, attenuation, and the coexistence of multiple hydrometeor populations. In particular, the retrieval of terminal velocity and vertical air motion is more uncertain in mixed-phase and melting regions and under strong precipitation, where attenuation and multiple scattering can also affect the radar measurements. We have therefore expanded the discussion of these uncertainty sources in Section 2.1.1 and interpret the corresponding results cautiously. We also cite the JAXA retrieval studies (Sato et al., 2009, 2025) for details of the retrieval assumptions and limitations.