Reviewer’s comments on “EarthCARE Observations of Vertical Motion and Cloud Microphysical Structure in Tropical Cyclones” by Huang et al.

General Comments

This paper examines EarthCARE observations of tropical cyclones (TCs), focusing on the vertical structure of radar reflectivity, Doppler velocity, vertical air motion, and cloud particle types. Based on 14 months of observations, the authors compiled a few hundred to a few thousand snapshots of TC-related clouds and precipitation, depending on the distance from the TC center. Radial composites of the above variables were then constructed. In addition, the authors performed a NICAM simulation of Hurricane Humberto, which was sampled by an EarthCARE overpass through the storm center, and compared the simulation with the corresponding EarthCARE observations.

Overall, this is a useful study that will make a valuable contribution to the literature, as it represents the first spaceborne statistical characterization of TCs from the perspective of a cloud profiling radar (CPR) with Doppler capability. The observations provide a unique opportunity to jointly examine the cloud microphysics and dynamics of tropical cyclones.

The paper consists of two main components: (1) an EarthCARE-based characterization of tropical cyclones and (2) a comparison between EarthCARE observations and NICAM simulations. I find the first component to be strong, comprehensive, and well developed. In contrast, the NICAM–EarthCARE comparison is much more tentative. My primary concern is that the model evaluation is based on only a single case study (Hurricane Humberto), and the overall simulation of storm intensity for this case is rather poor (e.g., minimum sea-level pressure and maximum near-surface wind; see Fig. 8), with differences in storm intensity approaching 80%. It is entirely reasonable that a global storm-resolving model (GSRM) cannot faithfully reproduce every individual tropical cyclone. Such models are generally expected to perform better in a statistical sense than for individual storms. However, evaluating the model using only one case substantially limits the significance of the comparison. After all, it could simply be an unfortunate case in which NICAM failed to reproduce Hurricane Humberto particularly well. At the same time, asking the authors to perform NICAM simulations for a large sample of TCs comparable to the EarthCARE observational dataset would likely be impractical. Consequently, the second half of the paper is considerably less compelling than the first.

Another major point concerns the interpretation of EarthCARE's Doppler velocity measurements and vertical air motion. The paper should clearly state, early in the introduction or data section, that the EarthCARE CPR has a Doppler Nyquist velocity of approximately ±5 m s^{-1}. Vertical velocities exceeding this range are therefore aliased (folded). Without this explanation, readers, particularly those familiar with ground-based or airborne radar observations of tropical cyclones, may be surprised that the vertical motions within the hurricane eyewall rarely exceed 5 m s^{-1}. To be fair, this is not a flaw, but rather a consequence of the instrument’s design. EarthCARE's Doppler capability

was developed primarily to observe the relatively weak vertical motions associated with clouds such as cirrus and stratocumulus, rather than the intense convective updrafts found in tropical cyclones.

On balance, I recommend major revision. One option would be to remove the model-comparison section and focus exclusively on the EarthCARE observational results. Alternatively, the authors could substantially reduce the emphasis placed on the NICAM comparison. Presenting a single-case comparison in which the simulated storm intensity differs so substantially from observations ultimately weakens confidence in the model evaluation, especially since NICAM is not intended to function as a numerical weather prediction (NWP) model optimized for reproducing individual storms.

Specific Comments

- L29: Roh et al. (2026) is missing from the reference list.
- L43–44: The synergy between CPR and ATLID is not, by itself, what makes EarthCARE unique. CloudSat/CALIPSO already provided radar-lidar synergy. EarthCARE's distinguishing feature is that its CPR has Doppler capability, whereas the CloudSat CPR does not.
- L95–96: This sentence unnecessarily repeats the information already presented in L88–90.
- Fig. 1d: It should be explicitly stated that positive velocity denotes upward motion in this figure. By convention in radar meteorology, positive Doppler velocity usually indicates motion away from the radar, which would correspond to downward motion for a spaceborne radar.
- Fig. 1d: Readers familiar with ground-based or airborne radar observations of TCs may be surprised that Doppler velocities within the eyewall only reach about 6 m s^{-1}. It should therefore be explained that the EarthCARE CPR has a Doppler Nyquist velocity of approximately ±5 m s^{-1}, so vertical velocities exceeding this range are aliased (folded). A similar discussion should also be included for Figs. 2c and 2d to facilitate proper interpretation.
- Fig. 2 (and L127): Some statistics of the radius of maximum wind (RMW) should be provided for the general reader. For example, if a typical RMW is on the order of 50–100 km, this normalization implies that one unit of normalized distance corresponds to roughly 50–100 km from the storm center.
- Fig. 2a: I suggest plotting the actual counts rather than their logarithms. Since the counts span roughly 50–3000, the color scale can still be displayed on a logarithmic scale to preserve dynamic range. However, requiring readers to mentally convert values of 2.0–3.4 into powers of ten interrupts the flow of reading and interpretation. The same comment applies to Fig. 3a.
- L186: Is there a previous reference supporting the use of RMW = 5 as the boundary between the primary rainband and the outer rainband? If so, it should be cited.
- L195–205: The differing air-motion characteristics among the eyewall, rainbands, and outer region are arguably among the most important findings of this study. This section deserves substantially more discussion. In particular, how do these EarthCARE CPR results compare with previous studies based on ground-based or airborne radar observations? Relevant references should be included.

- Fig. 4: The rationale for compositing reflectivity and vertical air velocity on a Doppler velocity–height diagram should be explained.
- L281–283: It is not clear how terminal velocity is retrieved from particle size, shape, orientation, and temperature. Some explanation or an appropriate reference is needed. Figure 9 also suggests that the retrieved terminal velocity differs substantially from (V_{tz}), which warrants clarification.
- Fig. 8a: The four storm-intensity curves should be explicitly identified as IBTrACS observations.
- L354–355: I am concerned about the substantial discrepancy between the simulated and observed intensity of Hurricane Humberto. The maximum near-surface wind speeds differ by nearly 80%. Given such a large difference in the overall storm intensity, it is not surprising that the structural differences shown in Figs. 10 and 11 are also significant.