Response to Reviewer #2 of egusphere-2026-1453

Dear Reviewer #2,
Thank you very much for taking your time to evaluate our paper. Your comments are greatly helpful to improve the manuscript. We have revised the manuscript based on reviewers' comments as explained below with point-by-point responses to your comments. We believe that the revision appropriately addresses your comments and questions on the original manuscript, and hope that our revised manuscript now deserves to be published in *Atmospheric Measurement Techniques*.

[RC]: ***Reviewer's comment***
[AC]: **Author's comment**

[RC1]: *This paper summarizes the Doppler velocity accuracy, cloud detection altitude, and contamination with second-trip echoes for the EarthCARE/CPR operational mode, providing useful information for users of EarthCARE/CPR data. On the other hand, a quantitative evaluation of the observed values against theoretical values is required. Specifically, while Figure 3 shows the relationship between theoretical Doppler velocity error and PRF for each radar reflectivity value, a similar plot should be created using actual observation data, and the differences between them should be discussed.*

[AC1]: Thank you for your valuable comments on comparison between theoretical limit and observed Doppler velocity. Another reviewer raised a similar point and suggested that the theoretical information in Fig. 3 be merged into Fig. 5. Following the suggestion, we have revised Fig. 5 by adding the theoretical Doppler velocity error curves to the plot based on actual observational data (Fig. R1). In the theoretical calculations, we used the mean PRF values within the variable PRF ranges for each mode. This allows a direct comparison between theoretical expectations and observed values. It also allows us to examine the dependence of Doppler velocity error on PRF by comparing three operational modes, fundamentally consistent with what is shown in Fig. 3. We have added the following explanation:

- Lines 290–292 in the track-changed manuscript:
  "Dashed lines show the theoretical calculation of Doppler velocity measurement, derived from Eq. (3) following Doviak and Zrnic (1993). For these theoretical

calculations, the PRF was set to 7,350 Hz, 7,000 Hz, and 6,300 Hz for the 16-km, 18-km, and 20-km modes, respectively, corresponding to the mean values within the variable PRF ranges for each mode."

Compared with the theoretical random errors, the observed Doppler velocity STDs show behavior that is consistent with the theoretical values in terms of their decrease with increasing radar reflectivity (S/N ratio), increasing PRF, and increasing integration length. However, they are generally larger because the observed STDs include not only random measurement error but also contributions from natural variability. In addition, the use of SPU-A, which represents poorer Doppler measurement performance, also contributes to the larger observed values. One exception is found at −20 dBZ for the 1-km integration, where the theoretical value slightly exceeds the observed STD. This may be due to the use of a fixed PRF in the theoretical calculation, whereas the actual PRF varies with latitude. We have added the above discussion as follows:

- Lines 292–299 in the track-changed manuscript:
  "The findings from Figs. 5a and 5b are fully consistent with the theoretical estimates of random Doppler velocity error; however, when focusing on the absolute STD values, the observed STD is generally larger than the theoretical value. This is because the observed Doppler velocity contains not only random measurement error but also components associated with natural variability. In addition, the use of SPU-A, which represents poorer Doppler velocity measurement performance compared to SPU-B, also contributes to the larger observed STD. One exception is found at –20 dBZ for the 1-km integration, where the theoretical value slightly exceeds the observed Doppler velocity STD. This may be attributable to the use of fixed PRF value in the theoretical calculation, whereas the actual PRF varies with latitude."

The ΔSTDs used in Figs. R1c and R1d effectively remove the contribution of natural variability under the assumption that the natural variability component is common among the modes within each reflectivity bin, implying that they can be directly compared with the theoretical random error estimates. Therefore, we have added the theoretical differences in Doppler velocity random error among the modes, shown as dashed lines in Figs. R1c and R1d. The theoretical and observed ΔSTDs are in good agreement, both exhibiting decreasing trends with increasing radar reflectivity, and the 20-km mode consistently shows larger values than the 18-km mode.

In contrast, the RDs in Figs. R1e and R1f do not effectively remove the natural variability component, therefore, theoretical values are not shown. Instead, they provide a normalized measure of the relative differences in Doppler STD with respect to the 16-km mode. As such, the RDs highlight the relative magnitude of the degradation in Doppler measurement performance among the modes, regardless of the absolute STD values. We have added the above discussion as follows:

- Lines 335–341 in the track-changed manuscript:
  "In addition, the theoretical differences in STDs shown in Figs. 5c–5d are in good agreement with the observations, both exhibiting decreasing trends with increasing reflectivity, and the 20-km mode consistently shows larger values than the 18-km mode. In particular, the theoretical and observed STD differences show very close agreement for the 18-km mode at the 1-km integration. The slight discrepancies between the observed and theoretical values likely arise from the aforementioned use of SPU-A, the use of a fixed PRF, and the possibility that the natural variability component is not completely removed."

In addition, following a suggestion from another reviewer, we have removed Fig. 6 from the manuscript, as it does not provide substantial additional information beyond what is already shown in Fig. 5. Our main conclusions are fully supported by Fig. 5.

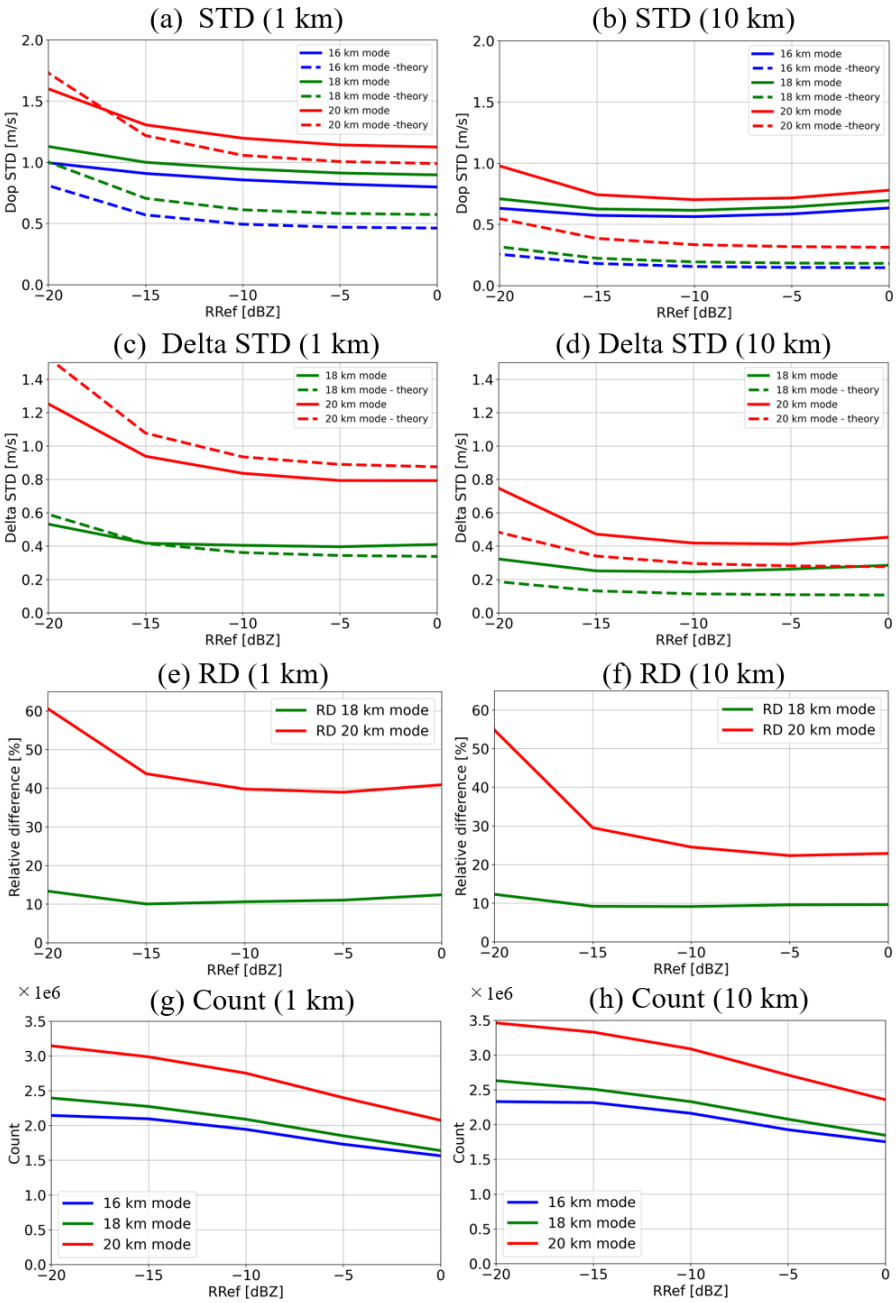

Figure R1: (a, b) STDs of Doppler velocity (m s^{-1}) as a function of radar reflectivity; (c, d) STD differences and (e, f) relative differences (%) of the 18-km and 20-km modes relative to the 16-km mode; and (g, h) sample counts for each radar reflectivity bin. The left and right panels correspond to the 1-km and 10-km integrations, respectively. The 16-km, 18-km, and 20-km modes are indicated by blue, green, and red lines, respectively. In panels (a)–(d), the solid and dashed lines represent observed values and theoretical estimates, respectively. The observed data from 1–12 November 2024 were used, and the analysis region is limited to latitudes within 60° and temperatures below 273 K. To ensure a consistent comparison among the modes, only clouds below 16 km were analyzed.

[RC2]: *As for other aspects, the revisions listed below should be implemented.*
10: The authors should mention that CPR is nadir looking radar

[AC2]: Thank you for your comment. We have added the following statement:

- Lines 10–11 in the track-changed manuscript:
  "The nadir-looking CPR operates in three observation modes…"

[RC3]: *13: "mirror images" should be "2nd trip echo from mirror images"*

[AC3]: Thank you for your comment. We have revised the wording as follows:

- Lines 12–13 in the track-changed manuscript:
  "…the likelihood of spurious high-altitude echoes known as second-trip echo from mirror images and multi-scattering tails."

[RC4]: *65: The authors should mention that CPR is w-band radar and nadir pointing.*

[AC4]: Thank you for your comment. We have revised the manuscript as follows:

- Line 67 in the track-changed manuscript:
  "The CPR, a W-band nadir-pointing radar onboard EarthCARE…"

[RC5]: *68: The authors should add Kobayashi et al. 2002 and Kobayashi et al. 2003.*
*Kobayashi, S., Kumagai H. , and Kuroiwa H. , 2002: A proposal of pulse-pair operation on a spaceborne cloud-profiling radar in the W band. J. Atmos. Oceanic Technol., **19 ,** 1294–1306.*
*Kobayashi, S., H. Kumagai, and T. Iguchi, 2003: Accuracy Evaluation of Doppler Velocity on a Spaceborne Weather Radar through a Random Signal Simulation. J. Atmos. Oceanic Technol., **20**, 944–949,*

[AC5]: Thank you for sharing references. We have added the proposed references (Lines 70–71 in the track-changed manuscript).

[RC6]: *96: The authors should concretely explain about the MIX-mode, in terms of original planning of CPR operation in one orbit (operating 20-km mode in low latitude and switching to 16-km mode in high latitude).*

[AC6]: Thank you for your comment. We have revised the manuscript as follows:

- Lines 97–99 in the track-changed manuscript:
  "Figure 2b corresponds to 1 November 2024, during which the CPR operated at latitudes lower than 60° and the 16-km mode at latitudes higher than 60° (see Section 2.2 for details)."

[RC7]: *100: "the CPR orbit altitude" should be "the nominal CPR orbit altitude"*

[AC7]: We could not find the phrase "the CPR orbit altitude" in the manuscript, but we assume the reviewer is referring to the "EarthCARE orbit altitude." We have revised the manuscript accordingly:

- Line 87 in the track-changed manuscript:
  "The relationships between latitude, nominal EarthCARE orbit altitude…"
- Line 123 in the track-changed manuscript:
  "The black dashed line indicates the nominal EarthCARE orbit altitude."

[RC8]: *140: "the CPR pulse wavelength" should be "the wavelength of CPR"*

[AC8]: Thank you for your comment. We have revised the wording as follows:

- Line 142 in the track-changed manuscript:
  "…where λ denotes the wavelength of CPR."

[RC9]: *Table 1 NB: the authors should explain the "data frame".*

[AC9]: Thank you for your comment. We have added the note of "data frame" to the caption in Table 1 in the track-changed manuscript as follows:

- Lines 167–169 in the track-changed manuscript:
  "Note that one data frame is defined as a basic Doppler processing unit and consists of 24 transmit–receive windows. Doppler velocity is estimated by integrating the returned signals within one data frame. The number of pulses, NB, is set to 22 because two or three pulses are not transmitted for noise sampling or calibration."

[RC10]: *Table 1 theta (definition box): "0.095° from CPR specification"*

[AC10]: Thank you for your comment. We have revised the definition box of theta in Table 1.

[RC11]: *168: "30 or higher"; please add the explanation what does it means.*

[AC11]: Thank you for your comment. We have added the explanation of cloud mask value as follows:

- Lines 176–177 in the track-changed manuscript:
  "Cloud areas were defined as regions where the cloud mask value in the product was 30 or 40, corresponding to good or strong cloud echoes, respectively,…"

[RC12]: *293: why the STD (10 km) at -20 dBZ in Fig. 6 is larger than that in Fig. 5?*

[AC12]: Thank you for your comment. The larger STD in Fig.6 may be attributed to the differences in natural variability. However, as noted in **[AC1]**, Fig. 6 has now been removed from the manuscript. Therefore, this discussion has not been included in the revised manuscript.

[RC13]: *Fig. 5 (g) (h): the y-axis label should be "Count".*

[AC13]: Thank you for your comment. We have revised Figs. 5g and 5h.