Final author response to referee (egusphere-2025-2697)

RC2: “Comment on egusphere-2025-2697”, Anonymous Referee #2

General comments

This manuscript provides an evaluation of the EarthCARE Doppler product using data from two vertically pointing surface radars, one in the Arctic and the second in Antarctica. The EarthCARE Cloud Profiling Radar (CPR) is a spaceborne W-band radar that measures the W-band reflectivity of clouds and precipitation, like its predecessor, the NASA CloudSat radar. The larger antenna used on the EarthCARE CPR provides improved horizontal resolution and sensitivity; however, it also allows the measurement of Doppler velocity for the first time for a spaceborne atmospheric radar. Hence, validating the EarthCARE CPR velocity measurements is timely. The methodology for the evaluation makes use of a recently developed CPR simulator, which allows the surface-based radar data to be converted to CPR-like data with error bars. These results are then directly comparable with the CPR data. As noted, the work is timely and should be of interest to readers. I think the manuscript is well-written; the reported analysis is well-described. I am curious if the authors plan to extend this study to other situations, like convective systems. I have some minor comments below.

The authors sincerely thank the reviewer for the careful reading of our manuscript and for the constructive feedback. The reviewer’s comments have been very helpful for refining our work.

Before providing detailed point-by-point responses to each comment, we would like to note one important update made during the revision process. To address comments raised by Reviewer #1, we extended the observation period June 2024 – February 2025 (~8 months) to June 2024 – July 2025 (~13 months). This extension required updating all figures and revising the associated text. Further detailed can be found in the revised manuscript.

Specific comments

Comment #1

Line 41 – the comparison with CloudSat indicates better resolution. Should this be better horizontal resolution? The vertical seems to be 500 m for both.

We agree with the reviewer that the vertical resolution of both spaceborne radars is about 500 m. To clarify, we have revised the sentence as follows:

(lines 39-42) “The EarthCARE CPR has higher sensitivity, better horizontal resolution, and reduced surface clutter contamination (Illingworth et al., 2015; Burns et al., 2016; Lamer et al., 2020) compared to the National Aeronautics and Space Administration (NASA) CloudSat CPR (Tanelli et al., 2008; Stephens et al., 2008, 2018).”

Comment #2

Sections 2.1 and 2.2.1 – these sections spend quite a bit of space on the sedimentation velocity. However, line 110 notes that "validation is conducted only from the perspective of the Doppler velocity best estimate." I'm not clear on this - does this mean that the comparisons are on the observed Doppler including both air motion and SVBE? If the study is just on the measured Doppler, then I'm puzzled by the space devoted to the sedimentation velocity. Please clarify. If sedimentation velocity is not really used in the comparison, I would shorten its mention to a couple of sentences.

We confirm that this study validates only the Doppler velocity. However, in the stratiform ice cloud cases considered here, where vertical air motion is typically weak, we assume that Doppler velocity biases are equivalent to sedimentation velocity biases, as described in lines 111-114 of the manuscript. Although sedimentation velocity is not directly part of the comparison presented, we included its description for context. This is because EarthCARE provides the first-ever global observations of sedimentation velocity, and this new capability will be of great interest to a much broader research community beyond the radar field. One of the central mission objectives is to enable the evaluation of fall speed parameterizations in weather and climate models. In this context, we considered it important to explicitly connect the Doppler velocities validated in this study to the sedimentation velocities that the wider community will use.

Comment #3

Line 130 – the horizontal velocity is assumed to be 9 m/s. Where does this come from?

The Orbital-Radar tool used in this study assumes a constant horizontal wind speed (default: 6 m s-1) throughout the whole atmosphere to perform the time – space conversion. To better represent high-latitude conditions, we updated the default to 9 m s-1 using radiosonde winds averaged below 10 km. However, over about one year of data, the daily mean wind speed exhibits large variability, and no single value can be considered optimal across the entire period and height range. Our assumption was that, given a sufficiently large sample, the mean vertical profiles of Z and V, as well as the Z-V relationship, would converge to climatological values, with random variability canceling out. This assumption was indeed supported by our results. When we extended the dataset from about 8 months to 13 months during the revision process, the mean Z and V profiles and Z-V relationships showed little change.

We added the following sentence in the revised manuscript.

(lines 164-165) "Even if this coordinate transformation is not optimal for every overpass, with a sufficiently large sample the measurements are expected to converge to climatological values."

Comment #4

Line 139 – I understand that we don't want to include more noise than necessary. However, I think maybe more detail would help convince the reader that the correct thermal and speckle noise levels are being used in the simulation.

In the revised manuscript, we have clarified the sentence as follows:

(lines 135-137) "For the Doppler velocity error, although the tool can reasonably estimate contributions from both satellite motion and receiver noise-related random error (i.e., thermal and speckle noise), our analysis incorporates only the satellite motion component to avoid overly noisy estimates."

Comment #5

Line 165 - can't things change quite a bit in three hours? I would think yes in the mid-latitudes but I'm not sure about the arctic. Is the difference in the times somehow included in the surface error bars?

We believe that our response to Comment #3 already addresses this concern.

Comment #6

Line 181 - are these offsets then applied to the surface-based radar data prior to running through the simulator?

Yes, these offsets are applied to the surface-based radar data prior to running it through the simulator. We revised the sentences as follows:

(lines 177-178) "As a result, calibration offsets of -2.1 dB for the NSA KAZR and -0.7 dB for the Neumayer FMCW radar were obtained, and these offsets were applied prior to processing with the Orbital-Radar tool."

Comment #7

Figure 2 and text starting around line 266 – I think there is a possibility of misinterpreting the bias correction. Specifically, the term "EarthCARE + e_p" could be interpreted as adding e_p to the EarthCARE observation, which would be the corrected EarthCARE. The caption does clarify that (b) and (f) are the EarthCARE before pointing correction. However, the authors might want to consider calling the uncorrected "EarthCARE" and the corrected "EarthCARE – bias" or EarthCARE – e_p".

We thank the reviewer for this suggestion. To avoid any possible misunderstanding, we have replaced "EarthCARE + e_p" with "EarthCARE (no e_p correction)" in Figure 2. The same update has also been applied to Figure 3.