ANSWER TO THE EDITOR

Manuscript egusphere-2025-1914 "First insights into deep convection by the Doppler velocity measurements of the Earth- CARE's Cloud Profiling Radar"

Public justification (visible to the public if the article is accepted and published):
Further minor revisions are required to the manuscript in response to the second set of reviews from the two reviewers.

Additional private note (visible to authors and reviewers only):
Dear authors, thank you for your revisions to your manuscript in response to the reviewers' comments. While both reviewers are positive on the overall merits of your paper, they have requested further changes. Please take a look at the second set of reviews they have provided, including the supplement provided by Reviewer 1, and provide a second revision to the manuscript and a response to their additional comments. In particular:

Reviewer 1 previously provided a detailed annotated version of your manuscript as a supplement to the first review and has expressed some frustration that many of the comments provided were not taken into account. Please take a close look at the new supplement provided by this reviewer and include in your response a point-by-point summary of whether you have taken into account what the reviewer has requested, and if not please provide your argument for not doing so. (I would also recommend you look back at the original supplement, but I am not requesting a point-by-point response to that.) I agree that there were many comments provided, particularly in the supplement accompanying this reviewer's first review, but these comments were all made in good faith to help you improve the manuscript. I agree with the reviewer that the title of the article should be changed (slightly) and that "Doppler" should have a capital "D", and would like to see your response to the other comments in the new annotated manuscript. However, please note that I agree with the authors that the Doppler sign convention matches the EarthCARE convention, and it is OK not to include the height of the melting layer from ERA5.

Reviewer 2 is concerned particularly that you need to convey to the reader more clearly that end-users should not trust velocities in the presence of multiple scattering. Three action items are provided in the new review, and I agree with them all. Comments 1 and 2 apply both to Figure 4 and Figure 5: the captions refer to blue circles when they should be referring to yellow circles. The point where the yellow circles stop indicates where multiple scattering starts to become important, so it would be appropriate to provide (for example) grey shading below this height behind panels 2 and 3 of Figs. 4 and 5 to indicate unreliable Doppler. And finally a comment in the text, probably the conclusion, is needed to state that the Doppler signal is not reliable in the presence of multiple scattering.

Dear Editor,

We thank you and the reviewers for the time and effort spent on evaluating our manuscript. We appreciate the constructive feedback and have carefully revised the paper in accordance with the comments provided in the second round of reviews. Below, we provide a detailed point-by-point response to all reviewer comments, indicating the changes made in the revised manuscript.

Sincerely,

The authors

ANSWER TO REVIEWER 1

Manuscript egusphere-2025-1914 "First insights into deep convection by the Doppler velocity measurements of the Earth- CARE's Cloud Profiling Radar"

Dear Authors,

First, I want to thank you for this revised manuscript.
As stated during the first round, your work presents interesting results about a very interesting mission, and I have no doubt that it will benefit the scientific community.

I am suggesting major revisions of the draft only because many of my suggested corrections from Round 1 were not taken into account (especially in Sections 2.1, 2.2 and 3). I found myself copying them again from Round 1.
This is not to harm your article but quite the opposite as I tried to write as many edits as I could.
For instance, during Round 1, I asked to please revise the title of the article, but that was not done. I asked to capitalize the name Doppler in the references but in vain. And, I still do not see the added value of Fig.5, i.e. the unique message that it contains and that is not already conveyed by Fig.4.
My comments (many of them copied from R1) are in the document attached and I hope you'll find them useful.

Regards

Dear Reviewer,

We would like to express our sincere gratitude for your careful evaluation of our revised manuscript and for the constructive and detailed comments you have provided.

We apologize for any oversight in the previous revision that led to some of your earlier suggestions not being fully addressed. We truly appreciate the time and effort you have dedicated to reviewing our work and for reiterating these valuable points.

We have carefully reviewed all of your current comments, including those reiterated from the first round, and we will ensure that the revised version of the manuscript fully incorporates your feedback. We are confident that these improvements will significantly enhance the quality and clarity of our paper.

Thank you once again for your insightful remarks and for contributing to the improvement of our study.

With kind regards,

First insights into deep convection by the Doppler velocity measurements of [1]the EarthCARE's Cloud Profiling Radar

Number: 1 Author: Subject: Comment on Text Date: 8/17/2025 2:09:34 AM

Please choose between The EarthCARE CPR

or

EathCARE's CPR

The title has been changed according to the suggestions.

Title changed to: “First insights into deep convection by the Doppler velocity measurements of the EarthCARE Cloud Profiling Radar”

extensively studied using observations from spaceborne radars.

The Tropical Rainfall Measuring Mission (TRMM), developed by the National Aeronautics and Space Administration (NASA) and the National Space Development Agency of Japan (NASDA), introduced the first spaceborne radar ~~in space~~, a 13.8 GHz Precipitation Radar (PR) (Kummerow et al. 1998; Kummerow et al. 2000). The TRMM PR was operational from

Number: 1 Author: Subject: Cross-Out Date: 8/17/2025 2:17:54 AM

you've already written that it's a spaceborne radar

This has been removed in the revised version of the paper.

convective cores and updrafts (Takahashi et al. 2017a). Findings indicate stronger convective cores and lower entrainment rates over land, enabling higher-altitude particle transport. However, CloudSat’s narrow across-track sampling (1.4 km cross-track) limits representation of spatially heterogeneous deep convective cores (DCCs). To mitigate biases, CloudSat data have been integrated with passive sensors, such as MODIS cloud top temperature, for improved convective characterization (Luo et al. 2008; Luo et al. 2010; Luo et al. 2014; K. Yang et al. 2023).

Number: 2 Author: Subject: Comment on Text Date: 8/18/2025 11:02:35 PM

Please review the grammar of this sentence (as suggested during round 1 of the review).

Maybe something like: "Because CloudSat was a nadir-looking radar and did not scan across its track, it was limited in its ability to capture the 3-dimensional spatial heterogeneity of DCCs".

Corrected with the suggested sentence.

An example of CPR observations of a deep convective system is shown in Fig. 1. The CPR observations were collected on September 19, 2024, over Western Africa on a descending (daytime) orbit. Here, CPR Level 2a (L2a) C-PRO data products

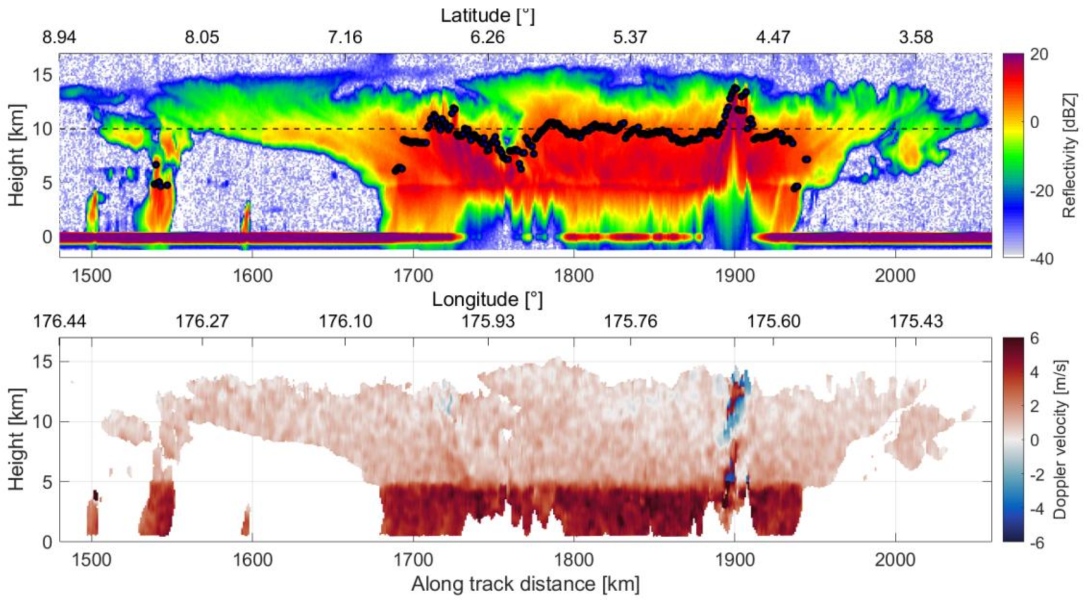
Number: 1 Author: Subject: Highlight Date: 8/18/2025 11:21:14 PM

Thank you for taking into account my comment and adding the latitude.

Would it be possible to have the longitude on top of the second subfigure instead of the latitude repeated?

For instance, to know if we're over Western Africa or the Pacific, one needs the longitude...

The longitude has been added to the Figure. Here below the updated version of Fig. 1.



In Fig. 1a the 10 dBZ echo top height is very close to the 10 km height for a significant part of the deep precipitating system. In two areas (1710-1730 km and 1890-1910 km along track), the 10 dBZ echo top height is well above the 10 km height and

Number: 1 Author: Subject: Comment on Text Date: 8/18/2025 11:30:36 PM
In Fig. 1a, the

The comma has been added in the revised version of the manuscript.

is 500 m, thus, a total of nine CPR Doppler velocity estimates (their respective real and imaginary parts of the lag-1 pulse pair estimator) have been averaged (Kollias et al. 2023). This averaging is immune to velocity folding. Before the along track averaging, the CPR Doppler velocities have been corrected for antenna mispointing (Puigdomènech Treserras et al. 2025) and non-uniform beam filling (NUBF) Doppler velocity biases (Kollias et al. 2014b; Sy et al. 2014).

Number: 1 Author: Subject: Highlight Date: 8/23/2025 8:29:04 PM
My question from Round 1 of the review has still not been addressed.

Please clarify: even though the averaging is done on the complex-valued quantities (lag-1 PP correls) the resulting Doppler velocity may still be aliased.

Does it mean that by averaging over such a long distance that you accept that you beat down the value of the velocity to a level much smaller than the Nyquist velocity? If so is it still useful in the presence of convection/updrafts?
Please clarify.

Added in the revised version of the manuscript:

“The averaging operation has to be performed in the lag-1 space, in order to avoid the cancellation due to opposite sign in the velocity space, that would lead to a wrong estimation of the Doppler velocity. Averaging over a larger number of pulses reduces aliasing but does not eliminate it, meaning that the Doppler velocity estimates remain susceptible to aliasing errors. Conversely, using a 4-km integration length constrains the ability to resolve the variability within convective cores, which typically occurs at sub-kilometer scales.”

2 he nadir-pointing CPR Doppler velocity V_D represents the sum of the vertical air motion W_{AIR} and the reflectivity-weighted Doppler sedimentation velocity of the hydrometeors V_T^D:

$$V_D = W_{AIR} \boxed{3} V_T^D. \quad (1)$$

Number: 2 Author: Subject: Highlight Date: 8/23/2025 6:19:30 PM
None of my comments (and there are a few) about this section was taken into account and I find myself repeating corrections from Round 1. Could you please explain? Those are mostly grammar/editing corrections.

Number: 3 Author: Subject: Comment on Text Date: 8/23/2025 6:16:21 PM
Noted. I have chosen not to fight the battle of the sign convention of teh Doppler velocity.

2: Sorry for that, the comments are addressed in the revised version of the manuscript.

3: We stick with previous convention as also recommended by the editor: negative velocity upwards (updrafts) and positive velocity downward (downdrafts).

The V_T 4 term can only take positive values (downward motion) while the W_{AIR} 5 rm can take both positive (downdraft) and

Number: 4 Author: Subject: Highlight Date: 8/23/2025 6:17:04 PM
term V_T^D

Number: 5 Author: Subject: Highlight Date: 8/23/2025 6:17:09 PM
term WAIR

Corrected in the revised version of the manuscript.

negative (updraft) values. The majority of the observed V_D in Fig. 1b are positive. This implies that the V_T 6 magnitude is higher than that of the embedded W_{AIR} updrafts. This suggests the presence of negligible vertical air motions ($|W_{AIR}| < 2m/s$). Because Doppler velocities are reflectivity-weighted, and non-Rayleigh scattering effects tend to reduce the reflectivity of large

Number: 6 Author: Subject: Highlight Date: 8/23/2025 6:17:35 PM
magnitude of V_T^D

Corrected in the revised version of the manuscript.

Because Doppler velocities are reflectivity-weighted, and non-Rayleigh scattering effects tend to reduce the reflectivity of large particles, the maximum reflectivity-weighted terminal velocity at W-band does not exceed 6.5 m/s. A typical example profile of the CPR Doppler velocity and corresponding radar reflectivity 7 stratiform precipitation conditions is shown in Fig. 2. In

Number: 7 Author: Subject: Cross-Out Date: 8/23/2025 6:20:23 PM
in

Corrected in the revised version of the manuscript.

of the CPR Doppler velocity and corresponding radar reflectivity 7 stratiform precipitation conditions is shown in Fig. 2. In
this 8 xample the Nyquist velocity is 5.09 m/s and the PRF is 6.38 kHz. The most pronounced V_D feature is its melting layer

Number: 8 Author: Subject: Highlight Date: 8/23/2025 6:21:00 PM
example,

Corrected in the revised version of the manuscript.

falling liquid raindrops around the 0°C isotherm (Fig. 2a). The 1-km CPR-averaged Doppler velocity profiles exhibit the same trend but [9]~~exhibit~~ considerable fluctuations (Kollias et al. 2014b). The noisiness of the CPR 1-km averaged Doppler velocities

Number: 9 Author: Subject: Cross-Out Date: 8/23/2025 6:27:51 PM
with

Corrected in the revised version of the manuscript.

trend but [9]~~exhibit~~ considerable fluctuations (Kollias et al. 2014b). The noisiness of the CPR 1-km averaged Doppler velocities makes the estimation of the hydrometeors' size and/or density [10]~~at the 1-km resolution~~ challenging (Kollias et al. 2022b; Mroz et al. 2023). The melting layer signature is also evident in the CPR reflectivity profile with a pronounced increase around the

Number: 10 Author: Subject: Cross-Out Date: 8/23/2025 6:28:08 PM

Author: Subject: Comment on Text Date: 8/23/2025 6:29:14 PM
You already state that things are at a 1km resolution in the beginning of your sentence

Corrected in the revised version of the manuscript.

0 °C isotherm (Fig. 2b). The ice-to-rain Doppler velocity transition is a well-known feature of the Doppler velocity in cold-rain systems, routinely observed by ground-based and airborne Doppler radars (Fabry et al. 1995; Heymsfield et al. 2010), but for the first time with [11]EC it is possible to see it from space.

Number: 11 Author: Subject: Underline Date: 8/23/2025 6:32:23 PM
Please either define EC as an acronym from the start of the article or use EarthCARE (already an acronym) throughout

I defined the acronym EC in the Introduction of the corrected version of the paper.

by the CPR without aliasing. [12]~~During~~ stratiform conditions, in the ice layer, velocity folding is rare even for the 1-km CPR Doppler velocity estimates (Fig. 2a). Below the melting layer, velocity folding occurs especially in the 1-km CPR Doppler velocity estimates, which are noisier. In Fig. 2a the 1-km Doppler velocity estimates outside the V_N boundaries have been

Number: 12 Author: Subject: Cross-Out Date: 8/23/2025 6:33:28 PM
In

Corrected in the revised version of the paper.

Figure 2. *(a) The CPR Doppler velocity profiles at along track distance of 1840 km. The 4-km CPR Doppler velocity estimate is shown [1]~~as~~ green circles and the 1-km Doppler velocity estimates within a 2 km distance from 1840 km are shown [2]~~as~~ gray lines. The yellow vertical lines indicate the CPR Nyquist velocity and the horizontal dashed line indicates the melting layer height. (b) [3]~~The~~ corresponding CPR reflectivity at along track distance of 1840 km.*

Number: 1 Author: Subject: Cross-Out Date: 8/23/2025 6:35:47 PM
as

Number: 2 Author: Subject: Cross-Out Date: 8/23/2025 6:36:00 PM
as

Number: 3 Author: Subject: Cross-Out Date: 8/23/2025 6:36:18 PM
The

Corrected in the revised version of the manuscript.

Figure 3. *(a) CPR reflectivity during a deep convective event ~~system~~ on September 18, 2024 over Western Africa (Frame 1752E). The blue*

Page: 7

Number: 1 Author: Subject: Comment on Text Date: 8/23/2025 6:41:37 PM

Thank you for organizing the figure like teh previous one. Please consider showing the longitude as well, e.g. instead of the latitude on top of Fig.B.

As above, for Figure 1.

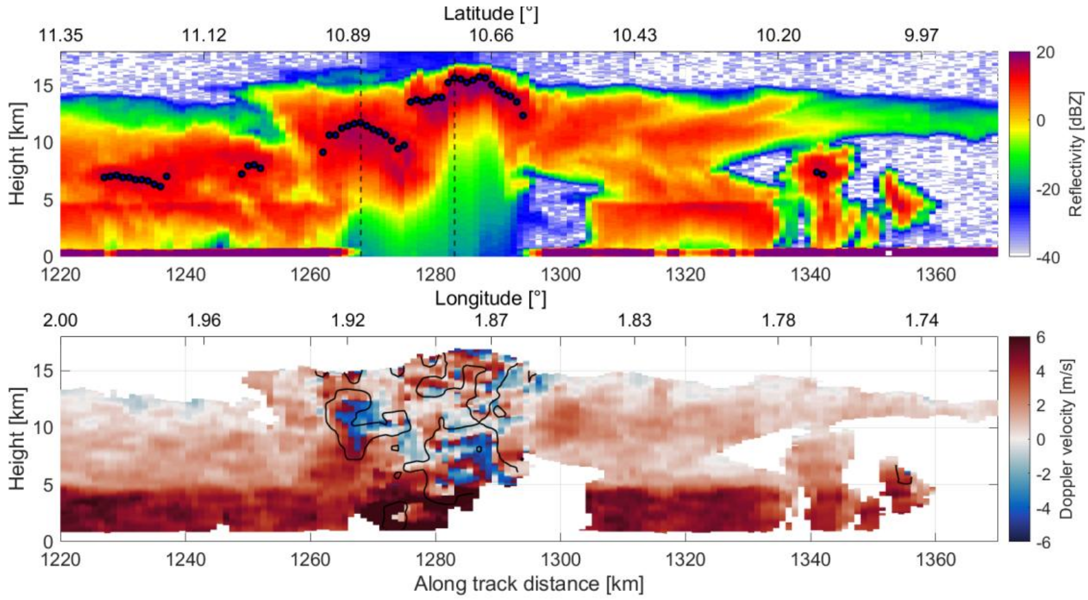


Figure 3. *(a) CPR reflectivity during a deep convective event ~~system~~ on September 18, 2024 over Western Africa (Frame 1752E). The blue*

Number: 2 Author: Subject: Cross-Out Date: 8/23/2025 6:40:35 PM

Corrected in the revised version of the manuscript.

profiles will be shown in later figures. (b) ~~the~~ CPR Doppler velocity measurements after a 4-km along-track integration (Kollias et al. 2023).

Number: 3 Author: Subject: Cross-Out Date: 8/23/2025 6:42:09 PM

The (it follows a period "." so should be capitalized)

Corrected in the revised version of the manuscript.

4.2 Deep convective scene

Number: 4 Author: Subject: Comment on Text Date: 8/23/2025 6:43:12 PM

Thank you for using the subsections. They are really helpful.

150 The complexity of the V_D profiles in deep convection is examined using a sample deep convective cloud (DCC) observed by the CPR (Fig. 3). The DCC is located between 1265 and 1300 km along track and is characterized by overshooting cloud

Number: 5 Author: Subject: Highlight Date: 8/23/2025 6:44:57 PM

Please state where this was observed. This is where have both lat and lon in the figure could help.

Latitude and longitude axes added to the figure, location (Western Africa, frame 1752E) added in the text in the revised version of the manuscript.

indicate the CPR gates where the Doppler velocity estimates are considered unaffected by multiple scattering. The green triangle indicates the height of the maximum radar reflectivity. (b) The 4-km CPR Doppler velocity profile [1]*(green filled circles) and the 1-km CPR Doppler velocity profile (gray filled circles). The black dashed vertical lines indicate the CPR Nyquist Doppler velocity. (c) The unfolded 4-km CPR*

Number: 1 Author: Subject: Highlight Date: 8/23/2025 6:50:20 PM
Thank you for taking my comment into account and varying the markers.

2 km vertically, centered on each pixel, to capture Doppler velocity variations in both the along-track and across-track [2] ~~Doppler velocity~~ directions.

Number: 2 Author: Subject: Cross-Out Date: 8/23/2025 6:49:23 PM

Corrected in the revised version of the manuscript.

is presented in Fig. 4a. The blue-filled circles mark the CPR range gates where Doppler velocity estimates are considered unaffected by multiple scattering. Additionally, V_D estimates near the cloud top are excluded [3] reflectivity falls below –15 dBZ.

Number: 3 Author: Subject: Highlight Date: 8/23/2025 6:53:03 PM
if the

Corrected in the revised version of the manuscript.

Beginning with the 4-km profile: near the cloud top, [1] ~~the~~ V_D is negative, indicating the presence of a weak updraft. Below 14 km, [2] ~~the~~ V_D turns positive, which may indicate the presence of large hydrometeors with high sedimentation velocity and/or a downdraft, resulting in an apparent downward motion. The abrupt jump of about 10 m/s in the profile at 12.5 km is attributed

Number: 1 Author: Subject: Cross-Out Date: 8/23/2025 6:56:38 PM
either remove or use "the value of V_D"

Number: 2 Author: Subject: Cross-Out Date: 8/23/2025 6:56:14 PM

1: Corrected with “the value of V_D”

2: Corrected with “the value of V_D”

a downdraft, resulting in an apparent downward motion. The abrupt jump of about 10 m/s in the profile at 12.5 km is attributed to velocity aliasing. In general if the absolute value of the difference between two consecutive Doppler measurements [3] ~~exceed~~ the Nyquist velocity, then adding $\pm 2\,V_N$ to one of the velocity produces a smoother [4] profile. Due to the noisiness of the

Number: 3 Author: Subject: Cross-Out Date: 8/23/2025 6:58:38 PM
exceeds: it's the abs value of the diffce

Number: 4 Author: Subject: Highlight Date: 8/23/2025 7:00:47 PM
yes but you also need to know which of the 2 points is the baseline (i.e. not unfolded) and which is not. This is actually a significant part of the logic underlying the dealiasing.

Please clarify in the text.

3: corrected in the updated version of the manuscript

4: We agree with reviewer on this. The major challenge in Doppler velocity unfolding arises from the absence of reliable boundary conditions, particularly within convective systems. In stratiform precipitation, it is generally reasonable to assume that motions below the melting layer are predominantly positive (downdrafts), which allows the unfolding procedure to be initiated upward from the top of the bright band. In convective environments, however, such an assumption is not valid. Furthermore, multiple scattering effects often compromise the reliability of measurements in the lower portions of the profiles. As a result, only the upper section of each profile can be considered sufficiently trustworthy. Therefore, the unfolding is performed in a top-down manner, computing velocity differences between successive gates from the highest gate downward, using as a boundary condition the uppermost gate with a sufficiently high signal-to-noise ratio (SNR).

This has been clarified in the text, in the section where the dealiasing is discussed.

the Nyquist velocity, then adding $\pm 2\,V_N$ to one of the velocity produces a smoother $\boxed{4}$rofile. Due to the noisiness of the measurements, the identification of a fold is not straightforward and there will be some ambiguity for successive points in the profile with jumps in $\boxed{6}_D$ close to $\boxed{7}_N$ (e.g. at 4-km integration $\boxed{5}$ngth values within 1 m/s from V_N are potential foldings). In

Number: 5 Author: Subject: Highlight Date: 8/23/2025 7:06:06 PM
length,

Number: 6 Author: Subject: Cross-Out Date: 8/23/2025 7:00:15 PM
V_D
Please be consistent with your notation

Number: 7 Author: Subject: Highlight Date: 8/23/2025 7:05:47 PM
V_N, please consistency in notation

5, 6, 7: Corrected in the revised version of the manuscript.

profile with jumps in $\boxed{6}_D$ close to $\boxed{7}_N$ (e.g. at 4-km integration $\boxed{5}$ngth values within 1 m/s from V_N are potential foldings). In
this $\boxed{8}$xample the difference is much larger, so folding is identified unambiguously and unfolding is straightforward. All the

Number: 8 Author: Subject: Highlight Date: 8/23/2025 7:02:06 PM
example,

Corrected in the revised version of the manuscript.

$\boxed{9}$he second profile is shown in Fig. 5. The CPR reflectivity profile is presented in Fig. 5a. This profile is selected from the elevated cloud top region of the deep convective cloud. In this case, the maximum CPR reflectivity is detected higher in the

Number: 9 Author: Subject: Highlight Date: 8/23/2025 7:09:58 PM
Please evaluate carefully if this second profile adds to the story of your article (which is already quite long). If it's only an additional illustration, I'd strongly encourage you to remove this part of the article and end the Section here.

This profile represents a different portion of the convective event, where the reliable section of the Doppler velocity profile is substantially smaller compared to that shown in Fig. 4. It is included here to illustrate the increased complexity of the unfolding process in convective regions where multiple scattering effects are significant and to highlight the potential ambiguities that arise when differences between consecutive range gates approach the Nyquist velocity (V_N).

Fig. 5c shows the unfolded 1-km and 4-km V_D profiles. In [1]e case, the section of the 4-km averaged V_D from the cloud top to [2]e height of 13.8 km is identified as aliased and corrected by subtracting 2 V_N. The unfolded 4-km profile displays a smooth vertical structure. A strong updraft is present above 12 km[3]~~eight,~~ and its magnitude exceeds 10 m/s near the cloud top.

Number: 1 Author: Subject: Cross-Out Date: 8/23/2025 7:09:00 PM
this

Number: 2 Author: Subject: Cross-Out Date: 8/23/2025 7:09:21 PM
a

Number: 3 Author: Subject: Cross-Out Date: 8/23/2025 7:12:02 PM

1, 2, 3: Corrected in the revised version of the manuscript.

[4].3 Analysis of Doppler velocity aliasing

Number: 4 Author: Subject: Highlight Date: 8/23/2025 7:12:40 PM
Thanks for splitting the long initial section into subsections

Based on comprehensive statistics from a large dataset of deep precipitating layers, the standard deviation of the along-track gradient of CPR radar reflectivity is[5]1.2 dB/km and 2.1 dB/km in stratiform conditions. Figure 6b shows the distribution of the

Number: 5 Author: Subject: Highlight Date: 8/23/2025 7:19:03 PM
As already asked during round 1: I do not understand
what are these two numbers. Are they limit values? modal values? quantile values? How to interpret them?

These values refer to the standard deviation of the dataset containing the along-track reflectivity gradient (in dB/km). The values in the new version of the manuscript have been recomputed and are now right (standard deviation of the reflectivity gradient is 5.25 dB/km and 1.67 dB/km in convective and in stratiform conditions, respectively). This gradient is computed as the difference in reflectivity between successive along-track gates, using a horizontal resolution of 1 km. High variability in the CPR reflectivity gradient—and consequently a high standard deviation—is expected in convective regions.

2022c). For our[6]ase this translates into[7]esidual random errors of 0.37 m/s in convective conditions and 0.07 m/s in stratiform conditions. The residual random errors in convection are five times higher than those in stratiform conditions, yet they are practically negligible considering the expected magnitudes of the convective updrafts and downdrafts.

Number: 7 Author: Subject: Comment on Text Date: 8/23/2025 7:21:51 PM
Sorry to insist on this, but I just don't understand what is the reference that you use to estimate these errors? IS it that you expect the signals to be 0 and measure a difference? Please clarify

This point has been clarified in the revised version of the paper: the Doppler velocity error is estimated by multiplying the reflectivity gradient by a correction factor. For EarthCARE, this factor is 0.165 m/s /(dB/km), resulting in a corresponding velocity bias. The residual random error is 20% of the velocity bias, as from literature. These values have been corrected accordingly to the comment 6 above.

finite horizontal scales. Moreover, the presence of multiple scattering and strong attenuation further limits the applicability of simplifying assumptions such as $W_{AIR} \approx$[2] below the melting layer[1]~~eight.~~

Number: 1 Author: Subject: Cross-Out Date: 8/23/2025 7:23:38 PM

Number: 2 Author: Subject: Comment on Text Date: 8/23/2025 7:23:36 PM
0 m/s

1, 2: corrected in the revised version of the manuscript.

Geostationary satellites today provide a quasi-global coverage in a [4]ide, common set of wavelengths [3]~~across different agencies~~, ranging from visible shortwaves to infrared (IR) (Fiolleau et al. 2024). Over the past decade, the capabilities of geostationary

Number: 3 Author: Subject: Cross-Out Date: 8/23/2025 7:29:32 PM

Number: 4 Author: Subject: Highlight Date: 8/23/2025 7:29:09 PM
wide and common

3, 4: corrected in the revised version of the manuscript

ranging from visible shortwaves to infrared (IR) (Fiolleau et al. 2024). Over the past decade, the capabilities of geostationary satellites have increased significantly in terms of spectral diversity [5]~~in~~ observations. A synergistic effort is currently underway to

Number: 5 Author: Subject: Cross-Out Date: 8/23/2025 7:29:52 PM
of

Corrected in the revised version of the manuscript.

satellites have increased significantly in terms of spectral diversity [5]~~in~~ observations. A synergistic effort is currently underway to merge imagery from the different instruments, recognizing the unprecedented spatial, temporal, and spectral coverage of Earth observation as a crucial contribution for the scientific and meteorological community. [6]arthCARE plays a primary role in the creation of this homogenized global observation product. [7]hese include advanced cloud and aerosol detection and property retrievals, as well as the ability to characterize these properties as a function of time. This temporal dimension enables deeper

Number: 6 Author: Subject: Comment on Text Date: 8/23/2025 7:27:18 PM
Unanswered Question from Round 1:

Why is that?

Number: 7 Author: Subject: Highlight Date: 8/23/2025 7:27:39 PM
Unanswered Question from Round 1:
What does the plural refer to here?

From line 234 to 240, the text has been changed to:

"Over the past decade, the capabilities of geostationary satellites have increased significantly in terms of spectral diversity and enhanced spatial and temporal resolution of observations. The synergistic use of these measurements with range resolved cloud and precipitation profiles offers a unique opportunity to the scientific and meteorological community. In particular, compared to CloudSat, EarthCARE offers finer horizontal resolution and is equipped with a Doppler radar. This enables, for the first time, global observations of in-cloud vertical velocities, thus deeper insights into convective storm lifecycle processes and the corresponding environmental responses."

the Atlas Mountains in North Africa, during a descending (daytime) orbit (Fig. 7). Figure 7a [9]how the visible band (0.6 µm) radiance from the MSG satellite, with the EarthCARE satellite ground track overlaid in red. Figure 7b displays the MSI brightness temperatures in the clean infrared band (10.8 µm). Several convective cloud complexes are detected, and some deep

Number: 9 Author: Subject: Comment on Text Date: 8/23/2025 7:32:30 PM
shows
(already from round1)

Corrected in the revised version of the manuscript.

Figure 7. *(a) Radiance from channel 1 (0.6 µm) of MSG, on November 7th, 2024 at 13:45 UTC. The EarthCARE ground track, corrected for the parallax is shown by the red line. (b) The MSI IR channel data from the EarthCARE satellite. The overpass time is 13:43 UTC on November 7th, 2024, frame 2530D. The red line is the satellite ground track. The segment between the two stars is plotted in Fig. 8.*

Number: 1 Author: Subject: Cross-Out Date: 8/23/2025 7:34:20 PM

Number: 2 Author: Subject: Cross-Out Date: 8/23/2025 7:34:18 PM
as

Number: 3 Author: Subject: Cross-Out Date: 8/23/2025 7:34:35 PM
The

1, 2, 3: Corrected in the revised version of the manuscript.

developed anvil reaches an altitude of 10 km and is primarily detrained southward from the main convective core. Between ~~38.4° and 38.5° latitude~~, a stratiform region is identified, characterized by a continuous reflectivity echo extending from the

Number: 4 Author: Subject: Cross-Out Date: 8/23/2025 7:38:18 PM
latitudes of 38.4 and 38.5
(Round 1)

Corrected in the revised version of the manuscript.

surface to cloud-top heights above 10 km. The melting layer is clearly marked by the presence of a bright band. North of this stratiform region, around 38.7° latitude, a stronger convective core is observed, featuring a thick reflectivity column ~~exceeding~~ 15 dBZ. This core reaches nearly 12 km in echo-top height, overshooting the anvil cloud top. Furthermore, the cluster of

Number: 5 Author: Subject: Cross-Out Date: 8/23/2025 7:39:27 PM
that exceeds
(you already use "featuring" in your sentence)

Corrected in the revised version of the manuscript.

Number: 6 Author: Subject: Underline Date: 8/23/2025 7:37:23 PM
a latitude of 38.7·

Corrected in the revised version of the manuscript.

Between 36.5° and 36.75° latitude, high cloud-top echoes reaching 8–10 km, reflectivities exceeding 10 dBZ, and significant attenuation collectively indicate a well-developed convective system. Further south, between 36° and 36.3° latitude, the lower height of the reflectivity echo, combined with the presence of very high reflectivity between 4 km and 6 km, suggests a con-

Number: 7 Author: Subject: Highlight Date: 8/23/2025 8:00:51 PM
of latitude

Number: 8 Author: Subject: Highlight Date: 8/23/2025 7:57:25 PM
of latitude

Corrected in the revised version of the manuscript.

vective cell still in [1]~~s developmental phase – likely in~~ an earlier stage of its [2]~~fe cycle~~. In Fig. 8c, the orange line represents the number of Doppler velocity foldings per profile, while the blue line indicates the number of pixels per profile that exceed the stratiform range threshold ([-2 3] m/s).

Number: 1 Author: Subject: Cross-Out Date: 8/23/2025 7:58:25 PM

Number: 2 Author: Subject: Cross-Out Date: 8/23/2025 7:58:46 PM
lifecycle

Corrected in the revised version of the manuscript.

Using the CloudSat methodology, a DCC would have been identified in Cell 1 between 38.5° and 38.7° [3]titude (green bar on the right in Fig. 8a) whereas only the central tower in Cell 2, located around 36.5° latitude, would be classified as deep

Number: 3 Author: Subject: Highlight Date: 8/23/2025 8:01:47 PM
of latitude

Corrected in the revised version of the manuscript.

To place the CPR convective cloud snapshots within the context of their [4]fe cycle, observations from EUMETSAT's MSG satellite are analyzed. [5]~~ig.~~ 9 and 10 display the corresponding MSG SEVIRI 1.5 rapid scan frames from channel 9 (10.8 μm)

Number: 4 Author: Subject: Highlight Date: 8/23/2025 8:02:44 PM
lifecycle

Number: 5 Author: Subject: Cross-Out Date: 8/23/2025 8:03:33 PM
Figures (it's the beginning of a sentence)

Corrected in the revised version of the manuscript.

In contrast, Cell 2 is more isolated, which facilitates more effective tracking and [6]lows its evolution to be observed from the early stages. Fig. 10 reveals a secondary cold spot on the southwest side of the cell, which later merges with the main

Number: 6 Author: Subject: Highlight Date: 8/23/2025 8:10:19 PM
allows for

Corrected in the revised version of the manuscript.

Figure 9. *Successive images depicting the time evolution of the IR brightness temperature field 10 minutes before (a), 5 minutes before (b), closest in time (c), 5 minutes after (d) and 10 after (e) EarthCARE overpass 2530D on November 7th, 2024, zoom on cell 1. The colors represent the brightness temperature from channel 9 (10.8 μm)* [1]*MSG rapid scans. Black solid line* [2]*present the ground track of EarthCARE, corrected for parallax (dashed line is the original ground track). The black markers correspond to Fig. 8a. The black star is the minimum of the brightness temperature that is tracked.*

Number: 1 Author: Subject: Highlight Date: 8/23/2025 8:14:22 PM
measured by

Number: 2 Author: Subject: Highlight Date: 8/23/2025 8:15:00 PM
represents
(Round 1)

Corrected in the revised version of the manuscript.

based on cloud-top cooling rates. While *tobac* tracking provides valuable temporal context, it [3]can not capture the fine-scale vertical variability and internal dynamics revealed by the EC-CPR.

Number: 3 Author: Subject: Highlight Date: 8/23/2025 8:12:39 PM
cannot

Corrected in the revised version of the manuscript.

This discussion reinforces the limitations of relying solely on geostationary infrared cooling rates [4]~~for characterizing~~ convection. While IR observations are effective at capturing relatively large and isolated updrafts near cloud tops, embedded

Number: 4 Author: Subject: Cross-Out Date: 8/23/2025 8:13:22 PM
to characterize
(Round 1)

Corrected in the revised version of the manuscript.

as the horizontal and vertical extent, of convective updrafts and downdrafts. Doppler velocity-based detection of convective cores is compared with traditional reflectivity-based methods. This comparison is expected to inform a revision of the detection criteria used in previous spaceborne radar [1]studies.

Number: 1 Author: Subject: Highlight Date: 8/23/2025 8:20:12 PM
Please state briefly how that will be the case based on the findings of your article?

Lines 318-320 text has been changed to:

“Our case studies give evidence of differences in the detection of convective cores when Doppler velocity based instead of reflectivity based criteria are used. Future studies should investigate the impact of new Doppler velocity based criteria onto the climatology of occurrences of convective cores across Earth.”

Kollias, P., S. Tanelli, A. Battaglia, and A. Tatarevic (2014b). “Evaluation of EarthCARE cloud profiling radar [1]doppler velocity measurements in particle sedimentation regimes”. In: *Journal of Atmospheric and Oceanic Technology* 31.2. DOI: 10.1175/JTECH-D-11-00202.1 (cit. on pp. 3, 5).

Number: 1 Author: Subject: Underline Date: 8/17/2025 2:29:00 AM
Doppler (it's a Last name)

Corrected in the revised version of the manuscript.

Sy, O. O., S. Tanelli, N. Takahashi, Y. Ohno, H. Horie, and P. Kollias (2014). “Simulation of EarthCARE spaceborne [1]doppler radar products using ground-based and airborne data: Effects of aliasing and nonuniform beam-filling”. In: *IEEE Transactions on Geoscience and Remote Sensing* 52.2. DOI: 10.1109/TGRS.2013.2251639 (cit. on pp. 3, 5).

Number: 1 Author: Subject: Underline Date: 8/17/2025 2:35:02 AM
Doppler (it's a Last name, like Galfione)

Corrected in the revised version of the manuscript.

ANSWER TO REVIEWER 2

Manuscript egusphere-2025-1914 "First insights into deep convection by the Doppler velocity measurements of the Earth- CARE's Cloud Profiling Radar"

This revised manuscript is much improved over the previous revision.

I believe the section describing Doppler velocities during multiple scattering still needs some improvement. The current version still contains errors, and the manuscript should clearly state that Doppler velocity estimates are not reliable at range gates with multiple scattering. As written, the manuscript states that Doppler velocities in range gates containing multiple scattering are valid and should be trusted. This conclusion contrasts with the author's response to my comment #9.

I believe that stating the Doppler velocities are not reliable during multiple scattering is a positive finding and end-users should be warned to not trust velocities during multiple scattering.

We thank the reviewer for this important clarification and for emphasizing the need to better communicate the impact of multiple scattering on Doppler velocity reliability. We agree that Doppler velocity estimates in range gates affected by multiple scattering should not be considered reliable.

Action Items:

1. The figure caption for Figure 5 does not match Figure 5. The yellow circles in panel 5a are labeled "Reliable Doppler", but the text says, 'The blue filled circles...are considered unaffected by multiple scattering." Thus, the figure caption says that the blue reflectivity pixels below 12 km are not affected by multiple scattering, yet the yellow circles above 13 km are labeled as reliable. These two statements cannot be correct at the same time. Please fix the figure caption and/or the figure.

Solved. I changed the Fig. but I didn't update carefully the caption.

2. Figure 5b and 5c need some kind of marking to indicate where the radial velocities are not reliable. I suggest shading the height-velocity domain where the radial velocities are considered not reliable.

The shading to highlight the effect of Multiple scattering has been added to Fig. 5 and Fig. 4.

3. I believe that some of the text the authors made in the reply to reviewer should be included in the manuscript to indicate that the authors know that the Doppler velocities are not reliable during multiple scattering. This text was: "Doppler velocity measurements in regions affected by multiple scattering cannot be considered reliable. Although these regions were expected to exhibit significantly more noise, this is not always observed. This aspect needs to be further investigated in future studies. By adopting a conservative approach, the Doppler velocity values in such parts of convective cell profiles should not be trusted."

This text has been added in the paragraph where the multiple scattering effect is discussed:

"Doppler velocity measurements within regions affected by multiple scattering cannot be considered reliable. Although a marked reduction in the correlation between successive pulses—and consequently an increase in Doppler velocity noise—is expected in these regions, such behavior is not always observed. This inconsistency warrants further investigation in future studies. Adopting a conservative approach, Doppler velocity values within these portions of convective cell profiles should therefore be treated with caution or excluded from quantitative analysis.”