

Review of “Estimation of Wet Radome and Rain-Induced Attenuation in Cloud Radar Observations” by Bernard Oom and Dmitri Moisseev for AMT publication

This manuscript investigates the estimation of wet radome attenuation and rain-induced attenuation in cloud radar observations using collocated disdrometer measurements. The study addresses several important aspects, including:

1. A statistical model for estimating the uncertainty range of drop size distribution (DSD) parameters and radar variables.
2. Estimation of wet radome attenuation.
3. Estimation of rain-path attenuation in cloud radar observations.

The topic is relevant for cloud radar applications in precipitation conditions, and the manuscript contains useful analyses. However, several aspects of the methodology, assumptions, and interpretation require clarification and more detailed discussion before publication.

General Comments

- Please provide a clearer description of the radar radome, including its type, geometry, and material properties, since these characteristics directly affect wet radome attenuation.
- The disdrometer observations are used to estimate radome attenuation, but the detailed comparison procedure is not sufficiently described. For example:
 - Which radar height gates are used in the comparison?
 - How is the radar volume matched with the surface disdrometer observations?
 - What possible factors could contribute to differences between radar and disdrometer observations besides attenuation?
- Many radar-related details are mentioned throughout the manuscript, but the discussion is often brief and fragmented. It would improve readability if the relevant sources of uncertainty and correction factors were consolidated into a dedicated discussion section.
- Wet radome attenuation and rain-path attenuation should be discussed more clearly as two separate physical processes, including their assumptions, limitations, and correction methodologies.
- Several factors affecting radar–disdrometer comparison are mentioned in the Introduction (Lines 45–57) and later in Lines 130–146, including near-field effects, parallax errors, evaporation, and pointing errors. Please consolidate these factors and clearly indicate which effects are explicitly addressed in this study and which are not.
- The manuscript would benefit from a clearer explanation of the assumptions underlying the rain-path attenuation retrieval. In particular, please clarify under what atmospheric conditions the method is expected to work reliably.

Specific Comments

Introduction and Background

- **Line 23:** The manuscript mentions attenuation in the melting layer in the Introduction, but this topic is not discussed further. Does the melting layer affect the radar–disdrometer comparison or attenuation retrieval in this study?

- **Lines 49, 54, 57:** Please clarify what is meant by “computed radar retrievals.”
- **Lines 65 and 72:** These statements appear somewhat repetitive and could be consolidated.
- **Line 65:** Two chirp modes are mentioned. Besides of range difference, what are other setup difference between the two modes Which chirp configuration is used in this study?

Disdrometer Measurements

- The following description is confusing:

“The lowest and highest measurable range of drop sizes measured for liquid precipitation ranges from 0.2 mm to 8.0 mm... The minimum detectable drop size is 0.312 mm...”

Please clarify the difference between:

- measurable drop size range, and
- minimum detectable drop size.

Why are these values different?

- **Line 100:**
“...the raw data...”
Please clarify what is meant by “raw data” in this context.
- **Line 118:**
“...computed after 5 minute integration.”
Please clarify:
 - the native temporal resolution of the precipitation gauge data, and
 - what is specifically meant by “5 minute integration.”

Radar–Disdrometer Comparison

- **Line 133:** The manuscript discusses near-field effects, parallax errors, and evaporation as possible explanations for decreasing reflectivity toward the surface. However, only the near-field effect is discussed in detail later. What about the impacts of:
 - parallax errors, and
 - evaporation?
- **Lines 143–147:**
The statement regarding a 0.05° pointing error producing 4 dB corrections near the surface requires more justification.

Please explain:

- why such sensitivity occurs,

- how the correction factors are estimated, and
- whether there are references supporting these claims.

Since the lowest gates appear highly sensitive to pointing errors, why not exclude or increase the minimum usable range gate? Additionally, is it possible to estimate the actual beam pointing offset of the radar?

The discussion here also appears somewhat contradictory to the conclusions in Line 150.

- **Line 183:**
“...this effect is range dependent and will decrease with height...”
Please clarify the wording. Do you mean the effect decreases with increasing height?
- **Lines 175–180:**
Does the analysis of surface reflectivity and particle size under different relative humidity conditions support the interpretation that evaporation contributes to decreasing reflectivity toward the surface?

Rain Attenuation and DSD Assumptions

- **Line 224:** Another velocity–diameter power-law relation is introduced. How does this relation differ from Equation 2, and why is an additional formulation needed?
- **Line 274:** During normalization using min–max scaling, should the skewness of the PSD parameter distributions (shown in Figure 1) be considered?
- **Line 308:**
The manuscript states that radome attenuation is identified when the difference between computed and measured reflectivity exceeds the expected uncertainty.

Please clarify:

- which radar height is used for this comparison,
- what additional factors besides uncertainty and radome attenuation could contribute to the differences, and
- why the estimated radome correction in Figure 7c occasionally becomes negative.
- **Line 309:**
Please explain more clearly how rain-path attenuation is estimated from disdrometer-derived specific attenuation.

Specifically:

- What assumptions are made?
- What is meant by “ideal conditions”?
- How is the path-integrated attenuation retrieved from the reflectivity profile slope?

Event Interpretation

- **Line 345:**
“...heavy rainfall saturated the radome...”
Please clarify what is meant by “saturated the radome.” Do you mean complete water coverage of the radome surface?
- **Line 359:**
The manuscript states that the difference between gauge accumulation and disdrometer-derived accumulation exceeds the expected uncertainty.

This discussion is unclear for two reasons:
 1. In the figure, the light blue, black, and ensemble disdrometer estimates appear nearly identical. Please clarify what uncertainty estimate is being referenced.
 2. The comparison mixes accumulated precipitation differences with instantaneous measurement uncertainty. Please explain how these quantities are being compared.
- **Line 374:**
“...we assume that the whole column is characterized by these observations.”
Please clarify what “these observations” refers to.

Figures and Interpretation

- **Figures 7 and 8:**
Please explain:
 - how the corrected radar reflectivity in panel (b) is obtained, and
 - what quantity is shown in panel (d).
- **Figure 9 and Line 392:**
The manuscript states that only two profiles satisfy the criterion shown in Figure 9. Please indicate:
 - which two profiles satisfy the criterion, and
 - why the other profiles do not.
- **Line 368:**
Please include the lidar depolarization ratio observations since they are important for identifying melting layer boundaries.
- **Lines 392–394:**
The manuscript attributes differences to a seeder–feeder process and embedded cloud layers identified from attenuated backscatter observations.

Please explain more clearly:
 - how the embedded cloud layers are identified, and
 - what observational evidence supports this interpretation.
- **Lines 413–416:**
The description of embedded liquid cloud layers and their impact on attenuation requires further clarification. Please explain:
 - how these layers are detected,
 - how the melting-layer base is determined, and

- why lower cloud layers are assumed to have a stronger influence on attenuation.
- **Paragraphs 409–417 and Figures 10–11:**
These sections are difficult to follow and require substantially more explanation regarding the methodology, assumptions, and interpretation of the results.

Summary

The manuscript addresses an important topic for cloud radar attenuation correction, particularly under precipitation conditions. However, the current version requires clearer methodological descriptions, better separation of attenuation mechanisms, and more rigorous discussion of the assumptions and uncertainties involved in the radar–disdrometer comparison. Clarifying these issues would significantly improve the scientific clarity and overall readability of the manuscript.