This manuscript proposes an improved method for raindrop size distribution retrieval by combining dual-frequency radar DFR information, with the aim of reducing the well-known dual-solution ambiguity in the DFR–Dm relationship. The topic is relevant to radar meteorology and precipitation microphysics, and the manuscript addresses an important limitation of conventional DFR-based DSD retrieval methods, especially under weak-echo and light-precipitation conditions.

The proposed approach appears promising, and the reported improvement in the proportion of uniquely retrievable Dm values is encouraging. However, several key methodological issues need to be clarified before the manuscript can be considered for publication. In particular, the source and practical role of the W-band reflectivity require much clearer explanation, and the novelty of the proposed method should be more explicitly distinguished from previous studies.

1. The source and practical role of the W-band reflectivity must be clarified

The most important issue in the manuscript concerns the use of W-band reflectivity and DFR(Ka,W). The abstract states that W-band reflectivity is synthetically incorporated through scattering simulations based on measured DSDs. However, the instrument section only describes an X/Ka dual-frequency vertically pointing radar and a 2DVD disdrometer. No actual W-band radar measurement appears to be available.

Response : We sincerely thank the reviewer for raising this critical point regarding the source and practical role of W-band reflectivity. In the revised manuscript, we have made substantial modifications to explicitly address this concern, as detailed below:

(1) Title changed to reflect the proof-of-concept nature

The title has been revised to "The Proof-of-Concept for Raindrop Size Distribution Retrieval Using Combined Dual-frequency Radar DFR" (Revised manuscript, page 1). This explicitly signals to readers that the study explores a theoretical framework rather than an operational retrieval using actual three-frequency radar measurements.

(2) Abstract clarified the source of W-band reflectivity

The abstract now explicitly states: "This study demonstrates that W-band reflectivities obtained through scattering simulations based on measured raindrop size distributions, combined with the DFR(Ka, W) constraint, effectively mitigate the DFR(X, Ka)-Dm dual-solution ambiguity" (Revised manuscript, page 1). This directly clarifies that W-band reflectivities are synthetically derived, not observed.

(3) Retrieval framework diagram explicitly distinguishes simulation from observation

In Section 2.1 (Retrieval Framework), the caption of Figure 1 has been revised to explicitly indicate: "Blue arrows indicate the scattering simulation workflow, while green arrows represent the retrieval workflow for real radar observation data". This visual distinction ensures readers can immediately identify which components (including W-band reflectivity and DFR(Ka, W)) originate from T-matrix scattering simulations versus actual X/Ka-band radar observations.

(4) New dedicated discussion section (Section 5.1) addressing practical applicability

We have added a new subsection, "5.1 Practical Applicability of Ka-W Constraints", specifically to address this reviewer concern. This section explicitly states: "It is important to explicitly acknowledge that this study does not include W-band radar observations. The W-band reflectivities used herein were obtained entirely through T-matrix scattering simulations based on measured DSDs. Therefore, the DFR(Ka, W) constraint should currently be regarded as a theoretical assessment of its potential to mitigate DFR-Dm ambiguity, rather than a fully operational retrieval constraint that has been validated with real three-frequency radar data."

This section further discusses that practical implementation would require an actual X/Ka/W three-frequency radar system, and that real-world performance would be affected by W-band calibration accuracy, atmospheric attenuation, and signal-to-noise ratio limitations.

(5) Conclusions reinforced with explicit limitations

In Section 6 (Conclusions), we have added: "It is important to emphasize the W-band reflectivities were obtained through scattering simulations rather than actual radar observations, and the evaluation is based on a limited sample from a single observational site. The practical applicability of the Ka-W constraint for operational three-frequency radar systems requires further validation with real W-band observations and more extensive datasets covering diverse precipitation regimes".

These comprehensive revisions ensure that the manuscript now clearly distinguishes between the simulated W-band reflectivity (used as a theoretical constraint to resolve DFR ambiguity) and the actual X/Ka-band radar observations, leaving no ambiguity about the data sources or the current limitations regarding operational application.

2. The novelty of the proposed method should be more clearly distinguished from previous studies

The manuscript reviews several previous approaches for addressing the DFR–Dm ambiguity, including generalized DFR methods and differential dual-frequency radar equation methods. However, the distinction between the present method and previous work is not yet sufficiently clear.

Response : Thanks for your valuable suggestion. In the revised manuscript, we have strengthened the distinction from previous studies through the following modifications:

(1) Clarified the fundamental limitations of existing methods in the Introduction

The revised Introduction (Section 1) retains the review of previous approaches but more clearly positions them as the motivation for this study:

Liao and Meneghini (2019) proposed DFR* to avoid ambiguity by redefining the dual-frequency ratio (introducing a tunable coefficient γ), but this sacrifices the key advantage that DFR depends solely on Dm and introduces an undesirable dependence on Nw.

Iguchi and Meneghini (2022) used a differential form of the dual-frequency radar equation, which primarily mitigates the dual-solution under strong attenuation (intense precipitation) conditions, leaving weak precipitation unresolved.

GPM operational algorithm simply circumvents the problem by using the R–Dm relationship instead of directly addressing the DFR–Dm ambiguity.

By clearly stating these limitations, the revised text establishes that existing methods either alter the physical definition of DFR or are limited to specific precipitation regimes, thereby highlighting the necessity of a new approach.

(2) Explicitly articulated the core innovation mechanism in Section 2.1

The newly revised Section 2.1 (Retrieval Framework) explicitly states the physical principle distinguishing our method:

"The core concept of this method is rooted in the physical principle that the DFR at distinct frequency pairs, specifically X/Ka and Ka/W bands, exhibits distinct responses to variations in Dm."

"To resolve this ambiguity, DFR(Ka, W) is employed, which operates at higher frequencies and exhibits a significantly narrower ambiguity zone than DFR(X, Ka)-Dm."

This clearly differentiates our strategy from DFR: we do not modify the definition of DFR(X, Ka); instead, we preserve its physical meaning and resolve its ambiguity by introducing an additional, higher-frequency constraint. Unlike the differential equation approach, our method leverages the scattering regime differences between frequency pairs to constrain Dm, particularly effective for weak echoes where DFR(X, Ka) ≤ 0.

(3) Added the step-by-step retrieval procedure in Section 2.2 to demonstrate the unique architecture

The original manuscript only provided a brief overall strategy. The revised manuscript adds Section 2.2 (Retrieval Procedure) with an 8-step detailed workflow. This explicitly demonstrates the novel "dual-frequency observation + simulated third-frequency constraint" architecture:

Step 2: T-matrix simulations generate W-band reflectivity from measured DSDs.

Step 6: DFR(Ka, W) is specifically used to resolve ambiguity when DFR(X, Ka) ≤ 0.

This procedural detail makes it unambiguous that our method is not a simple extension of conventional dual-frequency techniques but a new framework that synergizes observed X/Ka data with theoretically simulated W-band constraints.

(4) Added Section 5.1 to explicitly define the proof-of-concept nature and theoretical innovation

The new Section 5.1 (Practical Applicability of Ka-W Constraints) states:

"The DFR(Ka, W) constraint should currently be regarded as a theoretical assessment of its potential to mitigate DFR-Dm ambiguity, rather than a fully operational retrieval constraint that has been validated with real three-frequency radar data."

(5) Strengthened the abstract and conclusions to highlight the unique contribution

The revised Abstract now leads with:

"W-band reflectivities obtained through scattering simulations... combined with the DFR(Ka, W) constraint, effectively mitigate the DFR(X, Ka)-Dm dual-solution ambiguity."

The Conclusions (Section 6) reiterate that this proof-of-concept framework "explores the potential of combining X/Ka-band radar observations with simulated DFR(Ka, W) constraints"—ensuring readers understand that the novelty lies in the simulation-based multi-frequency constraint strategy rather than in conventional dual-frequency retrieval.

3. The English language and grammar require careful revision

The manuscript contains a number of grammatical and stylistic issues that should be corrected before publication. For example, the section title "Compression the Ambiguous zone of DFR-Dm" is grammatically incorrect and could be revised to:

"Reduction of the Ambiguous Zone in the DFR–Dm Relationship."

Similarly, the conclusion begins with "A improved raindrop size distribution retrieval method," which should be corrected to:

"An improved raindrop size distribution retrieval method."

Response : We sincerely thank the reviewer for the careful reading and constructive suggestions regarding the English language and grammar. We have thoroughly revised the manuscript accordingly.

(1) Section title corrected. Following the reviewer's exact suggestion, the section title previously written as "Compression the Ambiguous zone of DFR-Dm" (Original manuscript, Section 3.6) has been revised to "Reduction of the Ambiguous Zone in the DFR–Dm Relationship" (Revised manuscript, Section 3.5). This revision corrects the grammatical error and uses the proper preposition and capitalization.

(2) Conclusion opening corrected. The sentence "A improved raindrop size distribution retrieval method was developed..." (Original manuscript, Section 5) contained an article error. In the revised manuscript, the Conclusions section (Section 6) has been rewritten to begin with: "This study presents a proof-of-concept DSD retrieval framework...", thereby eliminating the grammatical error entirely while also aligning the tone with the study's scope.

Beyond these specific corrections, the entire manuscript has been carefully proofread and polished to improve English grammar, style, and readability.

Other minor grammatical and stylistic issues throughout the text have been identified and corrected to meet the publication standards.

4. The figures should be improved for clarity and interpretation

Several figures are central to the manuscript but could be made clearer.

For example, Fig. 1 should explicitly distinguish between observed variables, simulated variables, intermediate retrieval products, and final outputs. This is especially important because the role of the W-band reflectivity is currently ambiguous.

Fig. 11 is one of the most important figures in the manuscript because it demonstrates the reduction of the ambiguous DFR–Dm region. The ambiguous zones, thresholds, and physical interpretation should be labeled more clearly.

Fig. 17 contains many panels and is somewhat difficult to read. The authors may consider separating the Dm and Nw results into different figures or improving the layout.

For Figs. 18 and 19, the number of samples in each reflectivity interval should be reported, either in the figure panels or in the caption.

Response : We sincerely thank the reviewer for the detailed and constructive suggestions on improving figure clarity. We have carefully revised the figures, captions, and associated text to address each concern.

Regarding Figure 1 (Retrieval Framework):

In the revised manuscript (Section 2.1), we have significantly improved the retrieval framework schematic to explicitly distinguish between different variable types. The figure caption now clearly states: "Blue arrows indicate the scattering simulation workflow, while green arrows represent the retrieval workflow for real radar observation data" (Revised manuscript, Figure 1). Additionally, the text explicitly explains: "Blue boxes denote the results from scattering simulations, and green boxes represent those derived from radar observation data." This color-coded and arrow-based distinction now explicitly separates: (1) observed variables (X/Ka-band radar reflectivities, 2DVD-measured DSDs); (2) simulated variables (W-band reflectivity, theoretical DFR–Dm relationships, attenuation coefficients); (3) intermediate retrieval products (attenuation-corrected reflectivities, DFR values); and (4) final outputs (Dm, Nw, LWC, retrieved DSD). This directly resolves the previous ambiguity regarding the source and role of W-band reflectivity.

Regarding Figure 12 (previously Figure 11, Reduction of the Ambiguous Zone):

Following the reorganization of the manuscript (with the addition of the μ cost-function analysis as Figure 11), this figure is now numbered as Figure 12. The caption has been enhanced to clearly label the ambiguous zones: "The black dashed area indicates the ambiguous zone when DFR≤0" (Revised manuscript, Section 3.5). In panel (a), blue dots represent DFR(X, Ka) and red dots represent DFR(Ka, W), providing immediate visual distinction between the two frequency pairs. In the main text, we have added explicit quantitative thresholds and physical interpretation: "the ambiguous zone for DFR(Ka, W) is confined to a Z_{Ka} range of approximately −20 to 20 dBZ, corresponding to Dm values between 0.3 and 0.8 mm... In comparison, the ambiguous zone for DFR(X, Ka) covers a much wider Z_{Ka} range of about −20 to 45 dBZ, corresponding to Dm values from 0.3 to 1.6 mm" (Revised manuscript, Section 3.5). These quantitative boundaries and physical explanations are now explicitly stated to guide the reader's interpretation of the figure.

Regarding Figure 18 (previously Figure 17, Retrieval Comparison):

We acknowledge the reviewer's concern that the 8-panel layout is dense. In the revised manuscript, we have reorganized the figure with a clearer caption structure: "Retrieved mass-weighted mean diameter (Dm) and normalized intercept parameter [$\log_{10}$(Nw)]. (a, e: the proposed method; b, f: the first conventional method; c, g: the second conventional method; d, h: the retrieved Dm and Nw of June 14, 2025 by the proposed method)" (Revised manuscript, Figure 18). The panels are arranged in a logical 2×4 layout with Dm results in the top row (a–d) and Nw results in the bottom row (e–h), facilitating systematic comparison. If the editor and reviewer prefer, we are prepared to separate this into two distinct figures for final publication: one dedicated to Dm retrieval comparison (panels a–d) and one to Nw retrieval comparison (panels e–h).

Regarding Figures 19 and 20 (previously Figures 18 and 19, DSD and Error Statistics):

We agree that reporting sample sizes is essential for statistical transparency and reproducibility. We have added the number of samples for each reflectivity interval in the revised figure captions.

Figure 19. The mean raindrop size distributions retrieved by conventional methods (DSD-est1, DSD-est2) and the proposed method (DSD-est) against the true values (DSD). a: Z < 20 dBZ, 655 samples; b: 20 dBZ ≤ Z < 30 dBZ, 466 samples; c: 30 dBZ≤ Z < 40 dBZ, 1281 samples; d: 40 dBZ ≤ Z < 50 dBZ, 394 samples.

5. Terminology and notation should be standardized

The manuscript should use consistent terminology and notation throughout. For example: Dm, Nw, and LWC should follow a uniform notation style.

Clear and consistent notation will make the retrieval procedure easier to follow.

Response : Thanks for your important suggestion. In the revised manuscript, we have systematically unified all symbols and terminology throughout the text, equations, and figures.