Review of "Light scattering and microphysical properties of atmospheric bullet rosette ice crystals" by Wagner et al.

Overall recommendation

This study presents unique measurements of bullet rosettes found in ice clouds, obtained using Particle Habit Imaging and Polar Scattering (PHIPS) during the CIRRUS-HL airborne mission. Simultaneous measurements of microphysical properties and angular intensity of scattered light from the same ice crystal provide unique and highly valuable information that was not previously available.

This study delivers an important result: bullet rosettes, and possibly other ice crystals, exhibit smaller asymmetry parameters than those derived from theoretical calculations that assume smooth crystal surfaces. The methodology and analysis employed in this study have both advantages and disadvantages. Although the PHIPS measurement itself is clear and straightforward, there is some confusion regarding the analysis of microphysical properties and their linkage to the measured scattered light and the theoretical calculations. More details are listed below.

Given this, I recommend that this manuscript be published in *Atmospheric Chemistry and Physics* after the concerns listed below are addressed. The specific concerns supporting this recommendation are detailed below.

Major concerns

1. lines 101 - 107

The distinction between the 4512 bullet rosettes (BRs) and the subset of 1292 BRs used for microphysical analysis is unclear. The top-left panel appears to show the maximum dimensions of BRs for both the 4512 and 1292 datasets (black dots, median values). In the top-right panel, the aspect ratio (AR_B) seems to correspond to the 4512 BRs, while the bottom-left panel (number of bullets) and the bottom-right panel (H_{FACOR}) appear to represent the 1292 BRs. Please confirm if this interpretation is correct and clearly indicate this in the manuscript, figures, or figure captions.

Additionally, there is a discrepancy between the BRs used for deriving microphysical properties (4512 or 1292) and the BRs selected for single-scattering properties (1549). Despite the capability of PHIPS to measure both microphysical and scattering properties simultaneously, the study does not establish a clear connection between these measurements. Instead, the single-scattering properties are presented as averages, potentially obscuring important details.

Presenting individual single-scattering measurements of BRs with their corresponding theoretical calculations would enhance clarity and robustness. If averaging is necessary, provide a clear justification for this approach and explain how it impacts the results. Given that the scattering phase function of bullet rosettes is less sensitive to orientation compared to columns, presenting individual measurements should be feasible and could enhance the clarity and robustness of the analysis.

2. line 126

It is unclear whether the hollowness factor is derived for all bullets within the same BR. If the hollowness factors are obtained from a subset of bullets (e.g., three bullets out of a six-branch BR), clarify whether the hollowness factor represents an average of these bullets. Additionally, confirm if each BR is assigned a single hollowness factor. Since PHIPS provides stereo images, explain how these images are used to retrieve the hollowness factors and how these factors are applied to the microphysical property calculations. According to Appendix B, it appears that an identical hollowness factor is applied to all bullets within the same BR. Please provide more detailed explanations in the manuscript to clarify this methodology, as the current description is confusing.

3. Since PHIPS captures stereo images (C1 and C2) for the same target, two sets of microphysical parameters (e.g., maximum dimension, aspect ratio, projected area) are obtained. Clarify how these two sets of parameters are handled in Figures 5-8 and 10. Are both sets shown separately, or are they combined into a single representation? If a single set is shown, explain the selection process for determining which set of parameters to use. Including this clarification in the manuscript will help avoid confusion.

4. line 179, 10,000 crystal orientations

The PHIPS measurements provide angular scattering intensities for BRs with fixed orientations. In contrast, the theoretical simulations assume 10,000 crystal orientations. In Figures 9 and 10, BRs with different geometrical configurations (e.g., bullet size, BR size, aspect ratio, number of bullets, and hollowness factor) are grouped together. This raises concerns about the validity of comparing these averaged measurements with the theoretical calculations. Additionally, the authors state that both solid and hollow rosette simulations are based on a single bullet configuration with seven bullets.

Please clarify whether the comparison between the averaged measurements and theoretical simulations is appropriate, given the differences in geometrical configurations. Discuss how these differences might affect the validity of the results and, if possible, provide an analysis of individual BR measurements to support the conclusions.

5. line 271

The term “retrieved scattering functions (without diffraction)” is ambiguous. Clarify whether these are theoretical calculations or actual measurements. Since the scattering functions extend to 0°, they appear to be theoretical calculations. If this is the case, specify the BR configurations used for these calculations. If the scattering functions are derived from measurements, explain the method for retrieving values outside the PHIPS measurement range, particularly in the forward scattering direction.

6. Figures 9-11

In Figure 9, the retrieved scattering functions are stated to exclude diffraction. Clarify whether the calculated asymmetry parameters (g) shown in Figures 10 and 11 also exclude diffraction. The minimal differences in g between Figures 9 and 10 are unexpected, as larger differences are typically observed when diffraction is included or excluded. Please provide a clearer explanation of this aspect and ensure that the figures accurately reflect the impact of diffraction on the asymmetry parameters.

Minor concerns

1. Were any aggregates of bullet rosettes identified in the dataset? If such aggregates were observed, a brief mention or discussion of their occurrence and characteristics would be informative. If none were found, a statement clarifying this would be helpful.

2. Throughout the manuscript, ensure consistent use of terminology when referring to the scattering phase function, angular light intensity, and directional light intensity. Using a single, consistent term will enhance clarity and reduce confusion for readers.

3. lines 255-256

The manuscript suggests that incorporating the hollowness factor (H_{Factor}) into the mass calculation should decrease the mass. However, the results show an opposite trend. Including a brief explanation in the manuscript would address this inconsistency.

4. Eq. B1

Equation B1 calculates the mean volume of bullets within a bullet rosette. This implies that the bullets within the same BR have different volumes, potentially due to variations in geometrical parameters such as L_B (bullet length), L_{HC} (hollowness length), or the hollowness factor. How did the authors handle these variations when calculating the mean bullet volume? Clarifying the approach used to manage these differences in geometrical configuration would improve the transparency and robustness of the analysis?

This manuscript contains several typographical errors, including those listed below. Additional errors may exist, so a thorough review is recommended to identify and correct them all.

Typographical and Editorial Corrections

Line 37: “dimenesion” → “dimension”

Line 71: “duing” → “during”

Line 87: “acquistion” → “acquisition”

Line 103: “Aditionally” → “Additionally”

Line 104: “a criteria” → “a criterion”

Line 105: “occured” → “occurred”

Line 110: Rephrase to: “bullet rosettes have bullets with cavities that begin at...”

Line 125: “assesed” → “assessed”

Line 141: “rossette” → “rosette”

Line 191: “temperatues” → “temperatures”

Line 193: “discrepency” → “discrepancy”

Line 264: “discrepency” → “discrepancy”

Figure 7 Caption: “roesttes” → “rosettes”

Line 323: “signficant” → “significant”

Line 341: “occure” → “occur”

Line 343: “sufficent” → “sufficient”

Lines 358-361: Clarify or correct the term “me” (likely a typo).

Line 418: “discrepency” → “discrepancy”

Line 438: “assesed” → “assessed”

Line 447: “j kg^{-1} K^{-1}” → “J kg^{-1} K^{-1}”

Page 20: Add missing references for (Thermofisher, 2024) and (Jones et al., 2013).

Figure 4: Correct the vertical axis label to “AR_B” instead of “A_R”.