**Assessment of Disdrometer Data Quality Control Methods for Precipitation Measurements Based on Wet-Bulb Temperature**

**By H. J. Kim *et al*.**

Reply to the referees' comments

In the following, the comments made by the referees appear in black, while our replies are in red, and the proposed modified text in the typescript is in blue.

**Referee #1 comments**

This paper represents a significant contribution to the field by improving the accuracy and reliability of precipitation data through the evaluation of quality control methods for precipitation measurement instruments, with a particular emphasis on the impact of wet-bulb temperature. The research is of considerable value. But revisions are required before publication.

Authors are grateful for reviewer's interest in this study and the many helpful suggestions for improving this manuscript. Replies to each major comments and minor comments are listed below.

**Major comments**

1. Line 98-101: In this part of the discussion, it is essential to include relevant references. Additionally, it is suggested that the authors polish the language of the entire text to improve its quality.

We agree. In order to reinforce the basis for the content regarding the relationship between the diameter and fall velocity of raindrops, as you mentioned, we added references to the sentence in question. We added a reference that explains that as the diameter of raindrops increases, their fall velocity also increases, and when the fall velocity increases to the point where buoyancy and gravity balance each other, the fall velocity reaches terminal velocity.

Page 4, line 97-101

"QC approaches for disdrometer data primarily rely on the falling velocity of raindrops. In the absence of a substantial wind influence or particle collisions during descent, the fall velocity of a raindrop tends to increase with its diameter, ultimately reaching a terminal velocity. Terminal velocity is achieved when the forces of air resistance and gravitational pull are in equilibrium, resulting in no further particle acceleration (Wang and Pruppacher, 1977; Ong et al., 2021)."

Page 41, line 744-745

"Ong, C. R., Miura, H., & Koike, M.: The terminal velocity of axisymmetric cloud drops and raindrops evaluated by the immersed boundary method. J. Atmos Sci., 78(4), 1129–1146. https://doi.org/10.1175/JAS-D-20-0161.1, 2021."

Page 42, line 782-783

"Wang, P. K., & Pruppacher, H. R.: Acceleration to terminal velocity of cloud and raindrops. J. Appl. Meteorol. Clim., 16(3), 275–280. https://doi.org/10.1175/1520-0450(1977)016<0275:ATTVOC>2.0.CO;2, 1977."

2. Line 238-240 : Given that the QC methods for the disdrometer were specifically designed to address rainfall, the variable Tw was employed to differentiate between rainfall and snowfall, thereby facilitating the verification of rainfall timing. I would like to know what exactly is meant by "rainfall timing." Does it refer to the start time of the rainfall or its duration? How is it verified? This issue is not mentioned in the subsequent discussion.

Thank you for your detailed comments. The "rainfall timing" mentioned in the sentence refers to the time when rainfall was observed using disdrometer such as 2DVD and PARSIVEL. Since previous studies have mentioned that differences in the distribution of rainfall and snowfall appear depending on Tw, this study conducted a detailed analysis of whether changes in precipitation characteristics (fall velocity) based on disdrometer observations appear depending on the $T_w$ variable. To improve readability, the sentence has been revised as follows.

♧ Page 10, line 239-241

"Given that the QC methods for the disdrometer were specifically designed to address rainfall, the variable Tw was employed to differentiate between rainfall and snowfall, thereby facilitating the verification of precipitation type."

3. Figure 9 may cause some confusion due to the presence of two dashed lines in the same color. It is recommended to make appropriate modifications to enhance the clarity and readability of the figure.

We appreciate your constructive feedback. In response to your suggestion, we have revised the lines depicting the fall velocity intervals of raindrops for each quality control method in Figure 9, converting them to solid lines to enhance clarity. Furthermore, we have modified the colors better to differentiate these lines from the observed fall velocities.

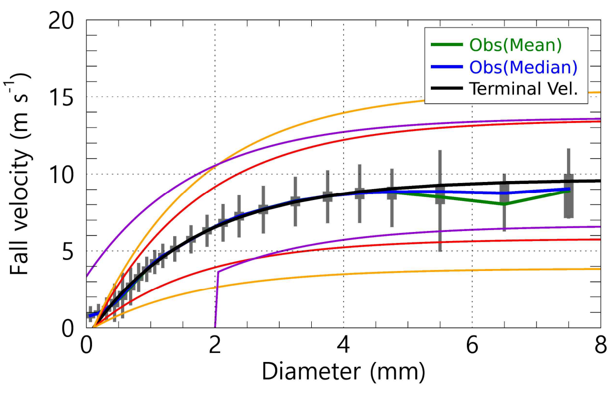


**Figure 9: Distribution of fall speed by diameter under conditions of $T_w \geq 5$ °C, and effective fall velocity of raindrops by pre-processing methods (The red (method 1), orange (method 2), and purple (method 3) solid lines represent the effective velocity of raindrop applied to each QC method).**

4. It is recommended to include a discussion on the limitations of the methods used in this paper. When discussing the effectiveness of the QC method at different wet bulb temperatures, should it also be influenced and constrained by factors such as the measurement location?

We agree. Previous studies (Ding et al., 2014; Hasager et al., 2020) have mentioned results on the classification of precipitation types (rain and snow) based on wet-bulb temperature. This study focuses on interpreting results obtained using ground-based disdrometers, rain gauges, and AWS data. Characteristics such as hydrometeor types are primarily influenced by environmental factors like temperature, making it challenging to determine changes in precipitation types solely based on the observation location of the instrument. Therefore, when conducting quantitative analyses using rainfall data from in-situ observation instruments, such as disdrometers and rain gauges, it is necessary to consider environmental variables, including temperature, in the analysis.

- Ding, B., Yang, K., Qin, J., Wang, L., Chen, Y., & He, X. (2014). The dependence of precipitation types on surface elevation and meteorological conditions and its parameterization. Journal of hydrology, 513, 154-163.

- Hasager, C., Vejen, F., Bech, J. I., Skrzypiński, W. R., Tilg, A. M., & Nielsen, M. (2020). Assessment of the rain and wind climate with focus on wind turbine blade leading edge erosion rate and expected lifetime in Danish Seas. Renewable Energy, 149, 91-102.

**Minor comments**

1. The units of the vertical axis in Figures 13 and 14 are inconsistent with the units described in the text. The author should carefully check this.

Thank you for your kind feedback. We have revised the text to make it easier for readers to understand the contents of the figures. In addition, we have clearly checked and reviewed the units of the vertical axis in Figures 13 and 14. The revisions are as follows.

♧ Page 20, line 403-414

"Precipitation measurements obtained from the disdrometer were derived from raindrop (or snow particle) accumulation. The quantitative errors associated with these precipitation measurements were assessed by comparing the filter rates of raindrops (or snow particles) using the QC method. Figure 13 shows the filter ratios corresponding to the Tw range and channel diameter. The two methods, Method 1 and Method 2, exhibit differences in the range of removal velocities based on particle diameter (see Fig. 9); specifically, Method 2 encompasses a broader spectrum of raindrop sizes compared to Method 1, leading to an increased filter rate when the Tw is below 0 ℃. Notably, the filter rate for Method 2 surpasses that of Method 1 at temperatures lower than -2 ℃. Conversely, Method 3 did not allow the removal of particles smaller than 2 mm (as indicated in CH 14), regardless of their low fall velocity, resulting in a consistent filter rate of 0%, irrespective of variations in $T_w$. This suggests that the number of particles smaller than 2 mm may be greater in Methods 1 and 2. Furthermore, the filter rate was lower when snow particles were assumed to have melted than when they had not melted. Nonetheless, for particles with a diameter of 1 mm or less, the filter rate ranged from approximately 10% to 30% when $T_w$ exceeded 1 ℃, which appears to be attributable to the removal of particles exhibiting a fall velocity that exceeds the raindrops."