Validation of Rainfall Data Analysis Using Disdrometer Data Under Wet-Bulb Temperature Conditions

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1. Introduction

To enhance the accuracy of rainfall estimation using remote sensing data, such as radar and satellite, it is crucial to improve the accuracy of the estimation relationships. Rainfall estimation is influenced by various factors, including rainfall type, geographical characteristics (e.g., inland and oceanic rainfall), and orographic rainfall features. Developing estimation formulas that account for variations in rainfall characteristics based on topography (elevation) and seasonal temperature changes is essential. Ensuring the reliability of observation data used in deriving these formulas is a top priority for achieving accurate rainfall estimation. This study evaluates the effectiveness of utilizing rain gauge data under varying wet-bulb temperature conditions to improve the reliability of rainfall analysis.

The analysis employed disdrometer data collected over **five years (2020–2024)**, applying channel-based particle diameter information and number concentration-based variable calculation methods to enhance the generalizability of the findings.

Quantitative comparisons of rain gauge observation accuracy under different wet-bulb temperature conditions were conducted, alongside an analysis of the temperature ranges in which two types of rain gauges (tipping-bucket and weighing gauges) could be effectively utilized.

Acknowledgement

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2. Data & Methods

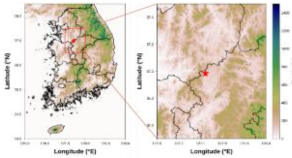

Fig 1. Location of ground observation station

Fig. 2. Two-dimensional video disdrometer

- **QC(filter) methods of disdrometer data for rainfall cases**

① Method 1 (40%) $\quad |V_{measured} - V_{ideal}| < 0.4 \times V_{ideal}$

② Method 2 (60%) $\quad |V_{measured} - V_{ideal}| < 0.6 \times V_{ideal}$

③ Method 3 (Raupach and Berne, 2015)

$$V_{measured} > V_{ideal} + 4, V_{measured} > V_{ideal} - 3$$

- **Terminal velocity of raindrops (V_{ideal})** (Atlas et al., 1973)

$$V(D) = 9.65 - 10.3\exp(-0.6D)$$

3. Results

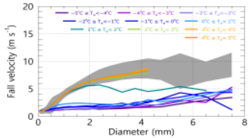

Fig. 3. Distribution of fall velocity by diameter in each T_w range. The grey area in the figure represents the Q1 (25%) – Q3 (75%) for the fall velocity by diameter when $T_w \geq 5$ °C.

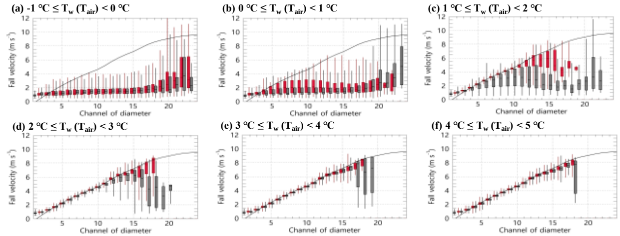

Fig. 4. Distribution of fall velocity by diameter channel based on T_w *(red)* and T_{air} *(gray)*. The black solid line represents the terminal velocity of rain drops proposed by Atlas et al. (1973).

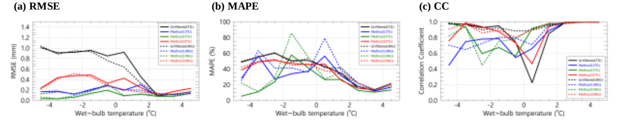

Fig. 5. Quantitative comparison of rainfall from a rain gauge (The solid line represents the tipping-bucket and the dash line represents the weighing rain gauge) and 2DVD by T_w.

4. Conclusions

- This study evaluated precipitation measurements using a 2DVD disdrometer alongside traditional rain gauges, finding high reliability (CC ≥ 0.98) when quality control (QC) methods were implemented under wet-bulb temperature (T_w) conditions 5°C or higher.
- When T_w drops below 2°C, particle fall velocity decreases and snow-rain mixtures occur, increasing measurement errors; in these conditions, appropriate snow particle density calculations and verification with weighing rain gauges are recommended.
- While the drop size distribution (DSD) shape remained consistent across different QC methods at $T_w \geq 2$°C, below this temperature threshold the DSD shape varied significantly between methods, indicating that disdrometer data should only be used for calculating DSD parameters and rain rates when collected in environments with temperatures of 2°C or higher.

References

- Atlas, D., Srivastava, R. C., and Sekhon, R. S.: Doppler radar characteristics of precipitation at vertical incidence, Rev. Geophys., 11, 1–35. https://doi.org/10.1029/RG011i001p00001, 1973.
- Raupach, T. H. and Berne, A.: Correction of raindrop size distributions measured by Parsivel disdrometers, using a two-dimensional video disdrometer as a reference, Atmos. Meas. Tech., 8, 343–365. https://doi.org/10.5194/amt-8-343-2015, 2015.