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A benchmark laboratory calibration dataset for tipping-bucket rain gauges: comparison of manual burette and automated methods

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Abstract

Reliable calibration data are essential for ensuring the accuracy and traceability of precipitation measurements obtained from tipping-bucket rain gauges (TBRGs), which are widely used in hydrological and meteorological monitoring networks. Although manual burette-based calibration remains the most commonly applied approach, its reproducibility is often limited by operator dependency and changes in discharge conditions during experiments. Automated calibration devices have been developed to address these limitations, yet publicly available benchmark datasets that allow transparent comparison between manual and automated calibration methods remain scarce.

This paper presents a benchmark laboratory calibration dataset for tipping-bucket rain gauges generated under controlled conditions using two calibration approaches: a conventional manual burette method and an automated calibration device (PRC-20AP). Calibration experiments were conducted at five target rainfall intensities (10, 20, 30, 50, and 100 mm h^{-1}), with a target total rainfall of 20 mm and 15 repeated trials for each intensity. For every trial, the dataset reports elapsed time, measured total rainfall, measured rainfall intensity, and corresponding relative errors.

In addition to raw measurements, the dataset includes intensity-wise summary statistics and a comprehensive uncertainty evaluation following the Guide to the Expression of Uncertainty in Measurement (GUM). Type A, Type B, combined, and expanded uncertainties at 95 % coverage are provided to support quantitative assessment of measurement repeatability and reliability. All data are released in machine-readable spreadsheet formats with detailed documentation of variables, units, and calculation conventions to facilitate reuse.

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The dataset is publicly available through a persistent DOI and is intended to serve as a reference benchmark for laboratory calibration of tipping-bucket rain gauges. Potential applications include calibration protocol validation, uncertainty budgeting, intercomparison of calibration methods, and the development and evaluation of automated calibration technologies for precipitation measurement.

1. Introduction

Precipitation data constitute a fundamental basis for hydrological and meteorological applications, including flood forecasting and warning, water resources management, and climate change impact assessment. The reliability of such data strongly depends on the measurement accuracy of precipitation instruments and on robust calibration frameworks. Among various precipitation sensors, tipping-bucket rain gauges (TBRGs) are one of the most widely used instruments worldwide owing to their simple mechanical structure, ease of automation, and relatively low maintenance requirements. However, it has been well documented that TBRGs exhibit rainfall-intensity-dependent measurement errors, with systematic biases occurring under light and intense rainfall conditions (Marsalek, 1981; Duchon and Essenberg, 2001; Habib et al., 2001; Tokay and Bashor, 2010). Consequently, regular calibration and performance evaluation of TBRGs are regarded as essential procedures for ensuring the quality of precipitation observations (WMO, 2008).

The most commonly adopted approach for laboratory calibration of TBRGs is the conventional manual burette-based method, in which a known water volume is discharged by gravity and compared with the rainfall recorded by the gauge. This method has long been used as a standard procedure because of its simple setup and operational practicality (WMO, 2008). Nevertheless, it inherently suffers from structural limitations, as the discharge rate gradually decreases with the lowering water level in the burette during experiments. In addition, the calibration results are strongly influenced by operator skill and procedural consistency, which can reduce repeatability and reproducibility and ultimately increase measurement uncertainty (Marsalek, 1981; Shedekar et al., 2009).

To overcome these limitations, automated calibration devices that actively control discharge conditions using precision pumps and sensors have been increasingly developed in recent years (Humphrey et al., 1997; Lanza and Stagi, 2009; Rohmah et al., 2024). Automated calibrators are attracting attention as viable alternatives to manual methods because they can minimize operator dependency and improve consistency across repeated trials. At the same time, the need for standardized and reproducible calibration procedures for rainfall intensity measurements has been continuously emphasized at the international level (Lanza and Vuerich, 2005; Colli et al., 2018).

Despite these developments, existing studies have largely focused on characterizing measurement errors of individual rain gauges or evaluating the performance of specific

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calibration devices. Publicly available datasets that provide raw experimental data together with uncertainty information derived from repeated experiments under identical and controlled conditions remain limited. In practice, rainfall gauge calibration often benefits more from well-controlled experimental datasets than from large-scale observational databases, particularly in the context of calibration protocol verification and standardization. However, such experimental benchmark datasets are rarely released in a reusable and well-documented form.

In this context, the present paper releases a laboratory calibration dataset for tipping-bucket rain gauges generated under controlled conditions using both a conventional manual burette-based method and an automated calibration device (PRC-20AP). The dataset consists of repeated calibration experiments conducted under multiple rainfall intensity conditions and includes measurement results together with uncertainty estimates evaluated following the Guide to the Expression of Uncertainty in Measurement (GUM) framework (JCGM, 2008). Although the dataset size is limited, it represents a practical and reusable reference dataset that can directly support calibration protocol validation, uncertainty assessment, comparison between manual and automated calibration approaches, and discussions on standardization of rainfall gauge calibration. Detailed performance analyses and interpretations based on this dataset are presented in Jang et al. (2026), while the primary objective of this paper is to systematically document the structure, generation process, and quality characteristics of the dataset itself.

2. Data description

2.1 Dataset overview

This dataset is an experimental, reference calibration dataset for tipping-bucket rain gauges (TBRGs), generated to support the comparison of a conventional manual burette-based calibration method and an automated calibration device (PRC-20AP) under identical and controlled conditions. The dataset was produced in a laboratory environment and consists of raw measurement data obtained from repeated calibration experiments together with derived statistical and uncertainty-related variables.

Unlike large-scale long-term observational databases, the present dataset is specifically designed for rainfall gauge calibration purposes. Although the overall data volume is limited, the dataset is based on repeated measurements conducted under strictly controlled conditions, which makes it particularly suitable for calibration protocol verification, uncertainty evaluation, and comparative studies between manual and automated calibration approaches. Performance analyses and interpretations derived from this dataset are reported in Jang et al. (2026), while the primary objective of this paper is to document the dataset itself in a transparent and reusable manner.

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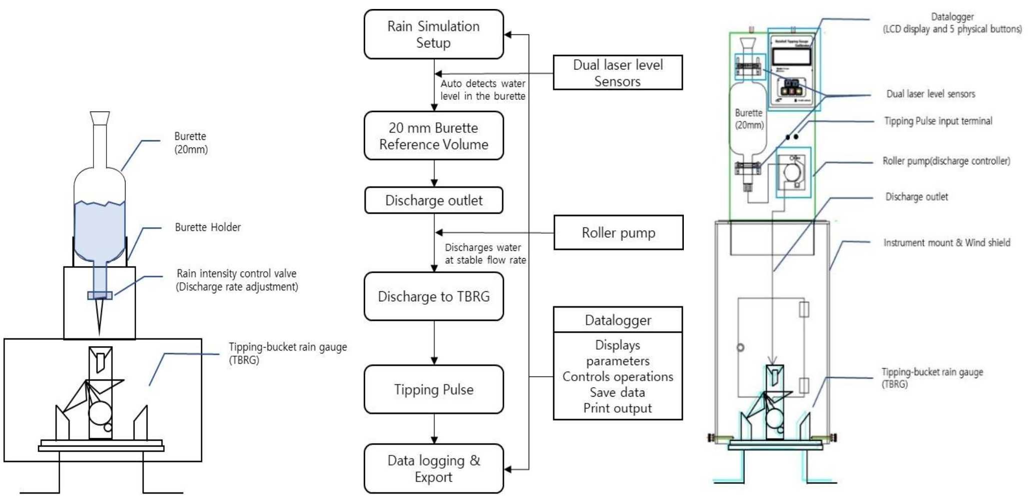
2.2 Experimental setup and instruments

The calibration experiments were conducted using both a conventional manual burette-based calibration system and an automated calibration device (PRC-20AP). The manual system follows the traditional gravity-driven discharge approach, in which a known volume of water is released through a burette and directed into the collecting funnel of the rain gauge under test.

The automated calibration device (PRC-20AP) is designed to actively control the discharge rate using a roller pump and a laser-based water level sensor. By continuously adjusting the pumping rate according to predefined rainfall intensity settings, the system maintains a stable discharge condition throughout each experiment. Additional technical details of the system design are provided in Jang et al. (2026).

The present dataset includes the results of repeated calibration experiments conducted using this system. Figure 1 presents conceptual schematics of the manual burette-based calibration system and the automated calibration system (PRC-20AP), highlighting the key components and flow paths relevant to data generation.



(a) (b)

Figure 1 illustrates schematic diagrams of the manual and automated calibration setups. (a) Manual burette-based calibration (schematic), (b) Automated calibration system (PRC-20AP, schematic), *(Adapted from Jang et al. (2026))*

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2.3 Calibration conditions and experimental design

Calibration experiments were performed under five rainfall intensity conditions: 10, 20, 30, 50, and 100 mm h^{-1}. For each rainfall intensity, the target total rainfall amount was set to 20 mm. Under each condition, 15 repeated calibration trials were conducted to enable the assessment of measurement variability and uncertainty.

Both the manual and automated calibration experiments were carried out using identical rainfall intensity and total rainfall settings. Environmental conditions other than the calibration method were kept as consistent as possible throughout the experiments. This experimental design allows differences between the two calibration approaches to be attributed primarily to the calibration method itself rather than to external factors. Table 1 summarizes the rainfall intensity levels, target total rainfall amounts, and the number of repeated trials applied in the calibration experiments.

Table 1. Summary of calibration conditions and experimental design applied to generate the dataset.

Parameter	**Value**
Calibration method	Manual burette-based / Automated (PRC-20AP)
Target rainfall intensities (mm h^{-1})	10, 20, 30, 50, 100
Target total rainfall (mm)	20
Number of repeated trials per intensity	15
Experimental environment	Controlled laboratory conditions

2.4 Data files and structure

The dataset is organized to clearly distinguish data generated using the manual burette-based calibration method from those obtained using the automated calibration device (PRC-20AP). Data are provided in separate files according to the calibration method, allowing users to easily identify and utilize the datasets without ambiguity.

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Manual calibration data are stored in the file experiment_manual_DIB.xlsx, while automated calibration data are stored in experiment_auto_DIB.xlsx. Each file contains both raw data obtained from individual calibration trials and summary data aggregated by rainfall intensity. The internal structure of the files follows a consistent worksheet layout, enabling identical analytical procedures to be applied to both manual and automated calibration datasets.

Within each calibration file, raw measurement data are stored in worksheets labeled manual_raw or auto_raw, and rainfall-intensity-based summary statistics are provided in worksheets labeled manual_summary_by_intensity or auto_summary_by_intensity. The raw data worksheets include time information for each trial, cumulative rainfall recorded by the tipping-bucket rain gauge, and calculated rainfall intensity values. The summary worksheets contain descriptive statistics derived from repeated trials, including mean values, standard deviations, and uncertainty-related metrics. In addition, each file includes a README worksheet that documents the data structure, variable definitions, and calculation conventions to facilitate correct interpretation and reuse of the data.

In addition to the calibration datasets, the file analysis_DIB.xlsx provides organized comparison and analysis results derived from both calibration methods. This file includes comparative results for total rainfall and rainfall intensity, estimates of relative error and uncertainty-based improvement metrics, and datasets prepared for figure generation. The detailed interpretation and discussion of these analysis results are reported in Jang et al. (2026) and are not repeated in the present data paper.

Figure 2 provides an overview of the repository structure of the dataset, illustrating the relationships between the manual and automated calibration data files and the organization of worksheets within each file. This repository structure was designed to allow users to intuitively understand the roles and contents of the data files and to efficiently access the information required for reuse.

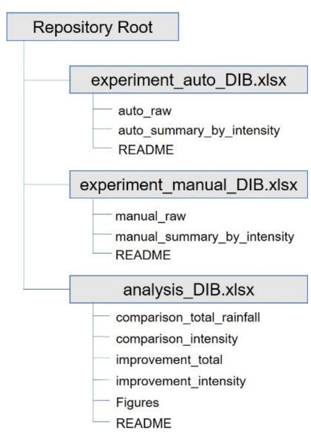

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Figure 2. Overview of the repository structure of the dataset, showing the organization of data files and worksheets for manual and automated calibration experiments.

2.5 Variables and units

The dataset includes raw experimental variables recorded during individual calibration trials and derived variables computed for statistical analysis and uncertainty evaluation. All variables are defined to be consistent with the worksheet structure and README descriptions provided in the distributed spreadsheet files (experiment_manual_DIB.xlsx, experiment_auto_DIB.xlsx, and analysis_DIB.xlsx).

Raw experimental data are stored on a per-trial basis, with one row corresponding to one calibration trial. These data include target setpoints, measured values obtained from the tipping-bucket rain gauge, and derived relative errors. Time-related information represents the elapsed time from the start of each calibration trial and is expressed in seconds (s).

The primary measured quantity is the accumulated rainfall recorded by the rain gauge during a calibration trial, expressed in millimeters (mm). Based on the accumulated rainfall and the trial duration, the average rainfall intensity is calculated and reported in millimeters per hour (mm h^{-1}). Relative error is defined as the difference between measured and reference values normalized by the reference value and is expressed as a percentage (%).

For each rainfall intensity condition, summary statistics are computed from repeated trials. These include mean values and standard deviations, which form the basis for uncertainty evaluation. Measurement uncertainty follows the Guide to the Expression of Uncertainty in Measurement (GUM) framework. Type A uncertainty is derived from repeated measurements as the standard deviation divided by the square root of the number of trials. Type B uncertainty is based on specification or certificate information for the calibration system. Combined standard uncertainty is calculated as the square root of the sum of squared Type A and Type B uncertainties, and expanded uncertainty is obtained by multiplying the combined uncertainty by a coverage factor corresponding to approximately 95 % confidence confidence ($t \approx 2.145$ for $n = 15$).

For summary and uncertainty variables, the applicable unit depends on whether the statistic is computed for accumulated rainfall or rainfall intensity, as specified in Table 2.

Table 2. Variables included in the dataset, their definitions and units.

For summary and uncertainty variables, the unit is mm when computed for accumulated rainfall and mm h^{-1} when computed for rainfall intensity.

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Variable name	Description	Unit
trial_id	Unique identifier for each calibration trial	–
rainfall_intensity_target	Target rainfall intensity set for the calibration experiment	mm h^{-1}
rainfall_total_target	Target total rainfall amount for the calibration experiment	mm
time_elapsed	Elapsed time from the start of a calibration trial	s
accumulated_rainfall	Accumulated rainfall recorded by the tipping-bucket rain gauge during a trial	mm
rainfall_intensity_measured	Average rainfall intensity calculated from accumulated rainfall and trial duration	mm h^{-1}
relative_error	Relative difference between measured and reference values	%
mean_value	Mean value computed from repeated trials at the same rainfall intensity	mm or mm h^{-1}
std_dev	Standard deviation of repeated measurements at the same rainfall intensity	mm or mm h^{-1}
u_A	Type A standard uncertainty derived from repeated measurements ($s/\sqrt{n}$)	mm or mm h^{-1}
u_B	Type B standard uncertainty based on specification or certificate information	mm or mm h^{-1}
u_c	Combined standard uncertainty calculated as $\sqrt{(u\_A^2 + u\_B^2)}$	mm or mm h^{-1}
U	Expanded uncertainty corresponding to approximately 95 % confidence ($t \approx 2.145$, $n = 15$)	mm or mm h^{-1}

3. Methods

3.1 Experimental design and workflow

Laboratory-based calibration experiments were conducted to generate a reproducible dataset for comparing manual and automated calibration procedures for tipping-bucket rain gauges. All experiments were performed at the calibration laboratory of the Korea Institute of Hydrological Survey (KIHS) under controlled indoor conditions. The experimental design focused on ensuring identical test conditions for both calibration methods, with differences limited to the water supply and rainfall intensity control mechanisms.

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Calibration experiments were conducted at five target rainfall intensity levels (10, 20, 30, 50, and 100 mm h^{-1}). For all test conditions, the target total rainfall amount was fixed at 20 mm. Each rainfall intensity condition was repeated 15 times for both calibration methods to support statistical evaluation based on repeated measurements.

Each calibration trial followed a consistent sequence of steps, as outlined below.

1) **Test condition setup**
   The target rainfall intensity and the target total rainfall amount (20 mm) were set for the calibration system. The tipping-bucket rain gauge was installed and checked prior to each trial.

2) **Initial water level preparation**
   Water was supplied to the calibration system to establish the reference volume. For the manual system, water was injected manually while visually monitoring the water level. For the automated system (PRC-20AP), water was initially poured above the reference level and then automatically discharged until the dual laser level sensors detected the exact target level.

3) **Water discharge and calibration run**
   Water was discharged toward the rain gauge at the prescribed rainfall intensity. Tipping signals from the rain gauge were recorded in real time. The duration of each calibration run was adjusted according to the rainfall intensity to achieve the target total rainfall amount (e.g., longer durations at lower intensities and shorter durations at higher intensities).

4) **Data recording**
   During each trial, the number of tipping events, elapsed time, and total discharged volume were recorded automatically. These measurements constitute the raw experimental data for each calibration run.

5) **Trial completion and repetition**
   A single trial was defined as one complete calibration run ending when the accumulated rainfall reached 20 mm. The same procedure was repeated 15 times under identical conditions for each rainfall intensity and calibration method.

The experimental workflow ensured consistent data generation across all test conditions, enabling subsequent statistical analysis and uncertainty evaluation based on repeated measurements. A schematic representation of the experimental workflow is provided in Figure 3.

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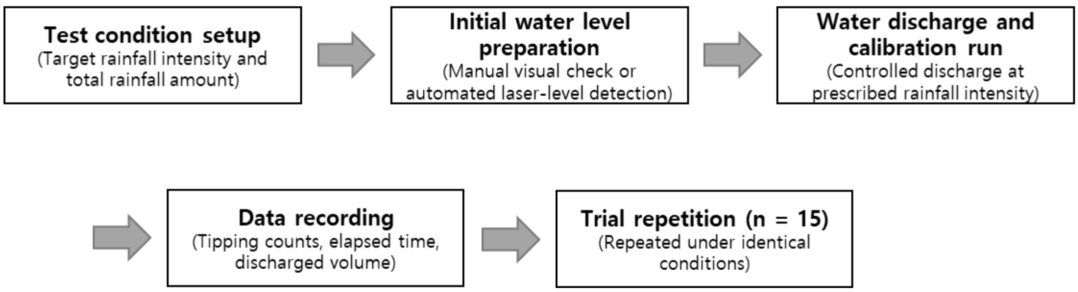

Figure 3. Experimental workflow for calibration data generation, illustrating the step-by-step procedure applied to each rainfall intensity condition.

3.2 Instrumentation

Two calibration systems were used to generate the dataset: a manual calibration system and an automated calibration system (PRC-20AP). Both systems were applied to the same tipping-bucket rain gauge under identical experimental conditions, and the differences between the systems were limited to the methods of water supply and rainfall intensity control.

The manual calibration system is based on a burette-type gravity-driven discharge setup and represents the most fundamental reference method for drop-based rainfall calibration. In this approach, an operator manually injects water and visually monitors the water level to establish a known reference volume. Once the reference volume is secured, water is discharged solely by gravity, and the rainfall intensity is adjusted by controlling the discharge rate. Owing to its simplicity and direct physical principle, this method has long been used as a baseline procedure for rainfall gauge calibration.

The automated calibration system (PRC-20AP) is a portable system consisting of a level sensor, a roller pump, and an electronic control unit. In this study, a laser-based level sensor was used to detect the reference water level with high precision, while the roller pump was employed to maintain a prescribed rainfall intensity by controlling the discharge rate. During the preparation stage, water is initially poured manually to a level above the reference volume, after which the system automatically regulates the outflow to secure the exact reference volume before initiating the calibration run.

Although PRC-20AP was used as the automated calibration device in this study, the experimental principle is not limited to a specific instrument configuration. The same experimental design and procedure can be applied to other automated calibration systems that establish a reference volume using level sensing and maintain rainfall intensity through pump-controlled discharge. Accordingly, the dataset is applicable to performance evaluation and comparative studies of a broad range of automated rainfall gauge calibration devices.

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The tipping-bucket rain gauge used in the experiments has a bucket resolution of 0.1 mm, consistent with specifications commonly adopted in international intercomparison studies. Prior to testing, all calibration systems were pre-calibrated by accredited national calibration institutes. The same rain gauge and installation conditions were maintained throughout the experiments to minimize the influence of external factors on the generated data.

3.3 Data acquisition

For each calibration trial, water was supplied to the tipping-bucket rain gauge until the accumulated rainfall recorded by the gauge reached the target total rainfall of 20 mm. Throughout each trial, the elapsed time and the number of tipping events were recorded in real time. The accumulated rainfall was obtained directly from the tipping counts and the corresponding bucket resolution, and the average rainfall intensity was calculated based on the accumulated rainfall and the elapsed time for each trial.

All measurements were recorded automatically by the data acquisition system associated with the calibration setup. Raw data for each trial include tipping counts, elapsed time, and discharged water volume, which together form the basis for subsequent data processing and uncertainty evaluation.

3.4 Data processing and uncertainty evaluation

Data processing was performed in a structured manner to derive summary statistics and uncertainty metrics from the raw experimental data. For each rainfall intensity condition and calibration method, repeated trial results were aggregated to calculate mean values and standard deviations for accumulated rainfall and rainfall intensity.

Relative errors were calculated by comparing measured values with the corresponding reference values defined by the experimental conditions. Measurement uncertainty was evaluated following the principles of the Guide to the Expression of Uncertainty in Measurement (GUM). Type A uncertainty was estimated from the statistical dispersion of repeated measurements, while Type B uncertainty was derived from instrument specifications and calibration information. The combined standard uncertainty was obtained by combining the Type A and Type B components, and the expanded uncertainty was calculated using an appropriate coverage factor corresponding to a confidence level of approximately 95 %.

Measurement uncertainty was evaluated following the principles of the Guide to the Expression of Uncertainty in Measurement (GUM; JCGM, 2008). Detailed implementation examples specific to rainfall gauge calibration are discussed in Jang et al. (2026). In the present data paper, only the essential principles and implementation overview are summarized to document the data generation and processing procedures.

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Detailed variable definitions, calculation rules, and uncertainty estimation steps are documented in the README worksheets included in the data repository.

4. Data quality and validation

The quality of the dataset is ensured through a controlled experimental design, repeated measurements, and standardized uncertainty evaluation procedures. All calibration experiments were conducted under predefined rainfall intensity and total rainfall conditions, with strict control of environmental and operational settings to ensure consistency and reproducibility.

For each rainfall intensity condition, 15 repeated calibration trials were performed for both the manual burette-based calibration method and the automated calibration method (PRC-20AP). The repeated-trial design enables a robust statistical characterization of measurement variability and supports the evaluation of random uncertainty components. Identical experimental conditions were maintained throughout the trials to minimize the influence of external factors on the recorded measurements.

Raw measurement data were recorded directly during each calibration trial and preserved without filtering, correction, or smoothing. This approach ensures full traceability from the original observations to the derived summary statistics. For each rainfall intensity condition, summary statistics, including mean values and standard deviations, were calculated from the repeated measurements and used as the basis for uncertainty evaluation and data quality assessment.

Measurement uncertainty was evaluated in accordance with the principles of the Guide to the Expression of Uncertainty in Measurement (GUM). Random variability was quantified based on repeated measurements, while systematic components were estimated from instrument specifications and calibration information. These components were combined to obtain standard and expanded uncertainty metrics corresponding to an approximate 95 % confidence level.

The consistency between raw data, derived statistics, and uncertainty metrics was verified through internal checks during data processing. In addition, the structured file organization and documented calculation conventions provided in the README worksheets support transparency, reproducibility, and independent reuse of the dataset. Together, these measures ensure that the dataset provides a reliable and traceable basis for rainfall gauge calibration studies, uncertainty analysis, and methodological comparisons.

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5 Data availability and access

The dataset is publicly available at Mendeley Data (Jang, 2025, https://doi.org/10.17632/czzzth6z26.3). The repository contains spreadsheet files with raw experimental data, summary statistics, and analysis results, as well as README worksheets describing the data structure, variable definitions, and uncertainty conventions.

The repository contains three main data files: (1) raw and summarized calibration data for the manual burette-based calibration method, (2) raw and summarized calibration data for the automated calibration method (PRC-20AP), and (3) a separate file containing comparative analysis results derived from both calibration approaches. The overall repository structure and the relationships between data files and worksheets are illustrated in Figure 2.

The dataset is intended to support reuse in rainfall gauge calibration studies, uncertainty analysis, and methodological comparisons between manual and automated calibration procedures. Users are encouraged to consult the README worksheets included in each data file for detailed guidance on data interpretation, variable definitions, and calculation conventions.

6. Potential applications

The dataset presented in this paper is intended to support a wide range of applications related to rainfall gauge calibration and uncertainty analysis. Owing to its controlled experimental design and repeated measurements under predefined rainfall intensity conditions, the dataset provides a structured basis for evaluating calibration procedures for tipping-bucket rain gauges.

First, the dataset can be used to assess and compare calibration results obtained using different calibration approaches. Although the present dataset includes results from a manual burette-based method and an automated calibration system, the experimental design and data structure are applicable to other calibration devices that employ gravity-driven discharge or pump-controlled water supply. As such, the dataset can serve as a reference for methodological comparisons across different calibration systems.

Second, the dataset is suitable for studies focusing on measurement uncertainty and repeatability in rainfall gauge calibration. The availability of repeated trials for each rainfall intensity condition enables statistical analysis of random variability and supports uncertainty evaluation following established frameworks. Researchers and practitioners may use the dataset to test alternative uncertainty estimation methods or to benchmark uncertainty levels under controlled laboratory conditions.

Third, the dataset may be used for the development, testing, and validation of data processing algorithms related to rainfall measurement. The inclusion of raw

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experimental data alongside summary statistics allows users to implement independent data processing workflows and to examine the effects of different calculation conventions on derived rainfall intensity and uncertainty metrics.

Finally, the dataset can support education and training activities in hydrometric measurement and calibration. The clear organization of data files, accompanying README documentation, and transparent experimental design make the dataset suitable for instructional purposes, including demonstrations of calibration procedures, uncertainty concepts, and data quality assessment in hydrological measurements..

7. Limitations

The dataset presented in this paper is based on calibration experiments conducted under controlled laboratory conditions and does not capture the full range of variability encountered under natural field conditions. Factors such as wind effects, spatial variability of rainfall, and variations in raindrop size distribution were not considered in the experimental design. Consequently, the dataset is intended to represent calibration characteristics and measurement consistency under controlled conditions rather than direct field performance.

The experiments were performed using a tipping-bucket rain gauge with a fixed bucket resolution of 0.1 mm. Rain gauges with different resolutions or structural characteristics may exhibit different measurement behavior and uncertainty characteristics. Additional calibration experiments would therefore be required to extend the applicability of the dataset to other rain gauge configurations.

Although the automated calibration approach was implemented using a specific device (PRC-20AP) developed and applied in this study, the underlying experimental principle is generalizable to other automated calibration systems based on level sensing and pump-controlled discharge. Nevertheless, differences in hardware configuration, control algorithms, or sensor performance may lead to variations in measurement characteristics.

Finally, the uncertainty evaluation included in the dataset is based on repeated laboratory trials and instrument specification information. Potential effects related to long-term operation, instrument drift, maintenance conditions, and operator-related variability were not addressed. Users of the dataset are therefore encouraged to consider these limitations when interpreting and reusing the data.

Author contributions

Jang, B. designed the study, conducted the experiments, curated and analyzed the data, and wrote the manuscript.

Competing interests

The author declares that there are no competing interests.

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References

Marsalek, J.: Calibration of the tipping-bucket raingage, Journal of Hydrology, 53, 343–354, 1981.

Sevruk, B. and Hamon, W. R.: International comparison of national precipitation gauges with a reference pit gauge, WMO Instruments and Observing Methods Report, No. 31, 1984.

Duchon, C. E. and Essenberg, G. J.: Comparative rainfall measurements by tipping bucket and weighing gauges, Journal of Applied Meteorology, 40, 1687–1693, 2001.

Habib, E., Krajewski, W. F., and Kruger, A.: Sampling errors of tipping-bucket rain gauge measurements, Journal of Hydrologic Engineering, 6, 159–166, 2001.

Tokay, A. and Bashor, P. G.: An experimental study of rainfall measurement by tipping bucket rain gauges, Journal of Atmospheric and Oceanic Technology, 27, 793–807, 2010.

Colli, M., Lanza, L. G., La Barbera, P., and Chan, P. W.: Laboratory comparison of rainfall intensity measurements from catching and non-catching type gauges, Atmospheric Research, 144, 39–50, 2014.

Lanza, L. G. and Stagi, L.: Performance analysis of a rainfall intensity measurement system, Advances in Geosciences, 20, 71–76, 2009.

Shedekar, V. S., Bales, S., Bhusal, N., and Zhou, M.: Design and evaluation of a low-cost tipping bucket rain gauge calibrator, Applied Engineering in Agriculture, 25, 223–228, 2009.

Humphrey, M. D., Istok, J. D., Lee, J. Y., Hevesi, J. A., and Flint, A. L.: A new method for automated dynamic calibration of tipping-bucket rain gauges, Journal of Atmospheric and Oceanic Technology, 14, 1513–1519, 1997.

https://doi.org/10.5194/essd-2025-791
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Duchon, C. E. and Biddle, C. J.: Undercatch of tipping-bucket gauges in high rainfall intensities, Journal of Atmospheric and Oceanic Technology, 28, 1005–1014, 2011.

Lanza, L. G. and Vuerich, E.: The WMO field intercomparison of rainfall intensity gauges, Atmospheric Research, 77, 200–218, 2005.

Tokay, A., Bashor, P. G., Habib, E., and Kruger, A.: Raindrop size distribution measurements by rain gauges, Journal of Applied Meteorology and Climatology, 45, 202–214, 2006.

Rohmah, D. Z., Jasruddin, S., and Utomo, B. S.: Development of an automatic portable calibrator for tipping bucket rain gauge, Journal of Physics: Conference Series, 2024.

Colli, M., Lanza, L. G., and La Barbera, P.: Towards a reference procedure for rainfall intensity measurements, Meteorologische Zeitschrift, 27, 215–226, 2018.

WMO: Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8), World Meteorological Organization, Geneva, 2008, updated 2018.

JCGM: Evaluation of measurement data — Guide to the expression of uncertainty in measurement (GUM), JCGM 100:2008.

Sevruk, B.: Precipitation Measurement, Swiss Federal Institute of Technology, Zurich, 1982.

Shedekar, V. S. and Tokay, A.: Uncertainty sources in laboratory calibration of rainfall measurement devices, Measurement, 67, 250–260, 2015.

Jang, B., Kim, G., and Kim, S.: Automation and accuracy improvement of field calibration for tipping-bucket rain gauges using laser sensors and roller pump, Flow Measurement and Instrumentation, 107, 103063, 2026.

Jang, B.: Laboratory calibration dataset for tipping-bucket rain gauges: manual burette vs automated device, Mendeley Data, V3, https://doi.org/10.17632/czzzth6z26.3, 2025.