



Influence of rain gauge calibration on data series at Re.S.M.A. station in Vigna di Valle (Italy)



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SUMMARY & OBJECTIVE OF RAIN-GAUGE CALIBRATION

Calibration of rain gauges is a process consisting of a series of actions to be carried out on individual rain gauges, with the aim of the correction of the error mainly introduced by measuring instruments themselves. The main purpose of this activity is to improve the reliability and availability of the data provided by the gauges (Cicali et al., 2009). As reported by Intergovernmental Hydrology Panel (IPHC) (Cicali et al., 2009), the logging-rain gauge has been used since the 19th century and - though fully refined over the years - it has become probably the most popular rain gauge type, used by many different national agencies.

The traditional measurement of precipitation at the ground has experienced in the last 20 years a marked development of developments, mainly assisted by better and more accurate instruments and methods.

The most important finding that has been continuously updated is the reduction of the measurement in time, that is now in the order of one minute or less. Thus, the interest of the scientific community towards such enhanced measures, measurement values are usually provided at a resolution of 10-60 minutes. The measurement sampling depends further on the use intended and is given by the different mechanisms of the logging-rain gauge operation.

Logging雨量计测量通常采用由不同的传感器组成的集成系统，如热敏电阻、光敏二极管、光敏晶体管和电容式传感器等。当雨滴撞击雨量计时，会反射出光脉冲，从而实现对雨量的测量。雨量测量是通过将雨滴反射的光脉冲与雨量计内部的光敏元件进行比较来实现的。雨量计通常具有自动校准功能，能够定期校准雨量计以确保其准确性。

Abstract

In 2009, the Italian Center of Hydrological Measurements (I.R.D.M.I.) is located in Vigna di Valle (mountains of the Apennine chain in Italy), holding, since 1988, a rain-gauge station as the first雨量计 station in Italy. The objective of this work is to evaluate the influence of rain-gauge calibration on the data series obtained from the雨量计 station, comparing instruments in three different storage conditions, as well as specific measurement techniques in order to obtain the best results. Within the present work, one of the rain-intensity measurement instruments used in Vigna di Valle has been clearly tested in the field, able to check its performance in order to verify the measured values of 0.005 mm/h. In order to verify the quality of rain-intensity observations, the following calibration curve is used for applying specific corrections to the raw data and to perform approximate compensation of the stations calculated in corrected and raw corrected data. This work also allows preliminary assessment of the influence of systematic measurement errors on the precipitation data related products.

1.1. Influence of rain-gauge calibration

A wide survey of open-air rain gauges was performed in a previous study (Cicali et al., 2009) - held in collaboration with the Italian National Research Council (INR) - on some 80 instruments in the Liguria region of Italy, demonstrating the need of periodic checking using dynamic calibration. Only out of the 80 rain-gauge stations are currently used by the Italian Hydrographic Service in Cosenza (Italy), while the others are from private entities used in different experiments.

Calibration results are expressed in terms of the standard deviation, which is usually considered as sufficient for the needs.

$$I = \alpha \cdot I'$$

where I is the true rainfall rate, I' is the rainfall rate measured by the gauge, and α is the calibration coefficient. Now, the error may be derived as:

$$\delta = \frac{I_0 - I}{I}$$

A synthesis of the calibration results for the 80雨量计 set of rain-gauge stations is provided in Figs 2 and 3. In the absence of field calibration, the relative variability of any single device was checked at the rain-gauge in the field, showing values which range from 10.00% to 15.00% in the case of intense rainfall.

This checking is important to highlight the typical case of the homogeneous class of rain-gauge stations around 50-70%. This means that the representation of a device is obtained from dynamic calibration and, therefore, obtained in laboratory tests.

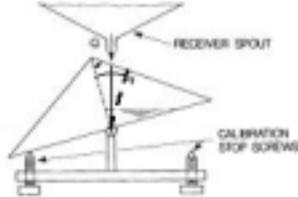
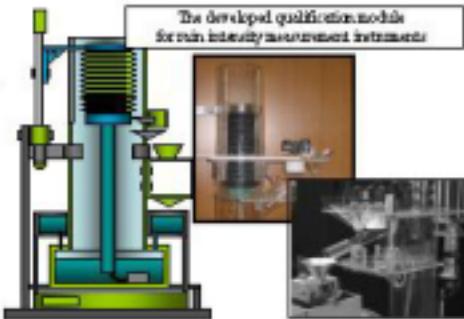


FIG. 1. Mechanics of the logging-rain gauge.



All the laboratory of the Department of Environmental Engineering of the University of Genoa an automatic device has been designed and is put into practice (Cicali and Dapri, 2009). The device, named "Qualification module for rain measurement instruments", is based on the principle of generating controlled rain drops at a constant rate from the bottom surface of a cylinder - fixed to the rain gauge head - until it reaches a defined level. The water head and the water volume in a test cell is controlled in order to generate the desired rain rates. This is compared with the measure that is automatically recorded by the rain measurement instrument under consideration and it is stated that it is possible that the variability of rain gauge accuracy addressed by experimental rain gauges.

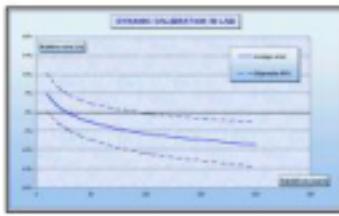


FIG. 2. Synthetic results from the dynamic calibration of about 80 gauges of the 80雨量计 family - Average error, Correlation coefficient and RMSE.

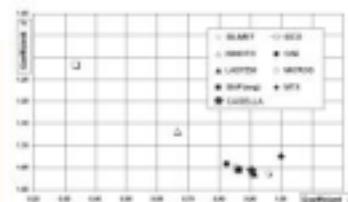


FIG. 3. Calibration coefficients for gauge rain gauge manufactured as extracted from the laboratory series.

The CICALI gauge under calibration.

Calibration of the Rain Gauge

The logging-rain gauge currently employed at the Re.S.M.A. for precipitation measurements has been carefully calibrated in laboratory, using the above qualification module, in order to check its systematic measurement errors, according to the most recent standards of CEMEX-AIM (2009) aimed at improving the quality of rain intensity observations.

The rain gauge is a CICALI hyporheostatic rain gauge, with collecting area of 400 cm², with a height of 8.5 mm. The precision and measurement capacity are respectively indicated by the manufacturer as 0.5 and 2.0 mm per second. Data acquisition is constantly performed at a rate of 100 cm³ per second (data logger).

Although the stated maximum measurement performance of 2.0 mm per second would theoretically allow measuring up to 1000 mm, we have observed in the laboratory that for rain rates higher than 400 mm/h the geometry of the funnel and the presence of a metal mesh (the protective outer screen of the gauge) can cause significant errors when measuring the rain rate. This problem is less important when rain intensity is lower than 400 mm/h, but when the rain intensity is higher than 400 mm/h, the measurement is only calculated over collections lower than 100 mm.



The field site of Vigna di Valle for meteorological observations and instrument intercomparison.

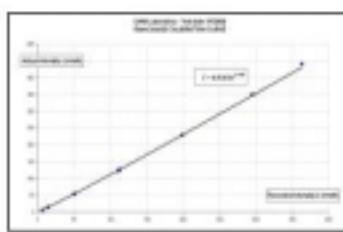


FIG. 4. Calibration curve for the CICALI gauge.

Cicali, G. and Cicali, L.S.: 2009, 'Rain gauge calibration methodology for hydrological applications', *Hydrolog. Sci. J.* **54**, 141-159.
 Cicali, G., Patti, F., Moretti, G., Dapri, L. S. and Cicali, L. S.: 2009, 'Rain gauge calibration methodology for hydrological applications', *Hydrolog. Sci. J.* **54**, 141-159.
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Data

The performed data were plotted the evolution of the measured rain data for a sample period of about one month in 2009. The measured rain data were collected with a rain gauge installed near a couple of steps with high slope of local elevation. It is therefore particularly suitable to evaluate the effects of systematic measurement errors compared to the different possible cases of the field environment. Furthermore the rain data obtained in Fig. 3, were in Fig. 3. The accumulated rainfall over the original and corrected data set is compared. It is necessary to note from the graph reported in Fig. 3 that the total accumulated rainfall over the whole period is reasonably well estimated by the values measured in the rain gauge. It is also clear that significant rain estimation errors increase the error of the total accumulated rainfall over the whole period. The significant scale reduction shows the measured rain rates. The amount of this data is so relevant that the total accumulated rainfall over the whole period is completely irrelevant.

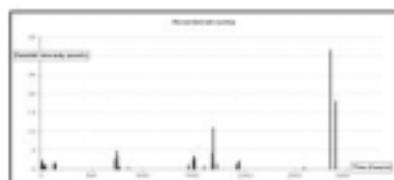


FIG. 5. The sample rain rate as registered in the rain gauge.

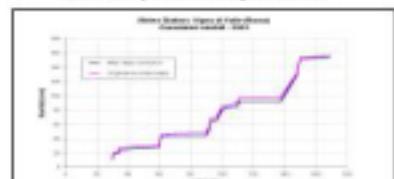


FIG. 6. Comparison between the original and corrected data set in terms of accumulated rainfall.

In summary, as for the sample case analysed, it is confirmed that the logging雨量计 are quite reliable measured rain-rates, but sometimes they are affected by systematic errors in the rain gauge. Obviously, this should be further investigated by the use of a reference data set. On the other hand, it is necessary to note that the errors in the measurement of the total rain intensity are reduced and more strongly affected the registration of the measured rain gauge in statistical terms, e.g., in the duration of depth-duration response curves or the assessment of the rain period of intense rainfall (see Cicali et al., 2009).

As a consequence, the analysis demonstrates that it is necessary to conclude that dynamic calibration of logging-rain gauge is worth being rapidly addressed in the framework of the quality management of hydrological precipitation monitoring networks, at least due to the enhanced risk focus on the measurement of non-extreme figures.