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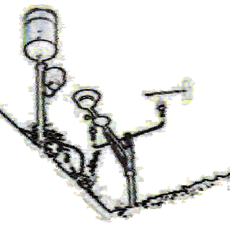

QUALITY STANDARDS FOR RAIN INTENSITY MEASUREMENTS

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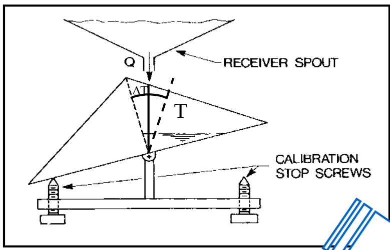
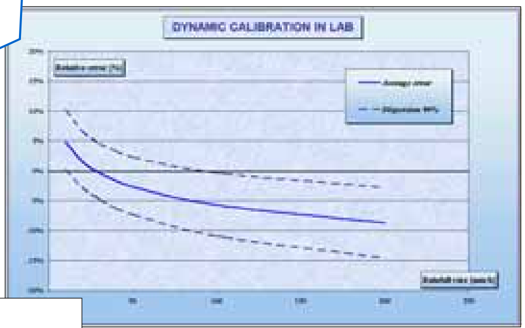
ABSTRACT

A suitable qualification module for rain intensity measurement instruments is proposed based on an automatic procedure for dynamic calibration of traditional Tipping Bucket Rain gauges (TBRs). Following an initial background of dedicated laboratory tests, which assisted in producing reference calibration curves for various types of commercial gauges from different manufacturing companies, the effects induced by systematic mechanical errors on the derivation of common statistics of rainfall extremes have been quantified. This research provides the needs and the requirements for the development of quality check procedures that can be easily shared among rain gauge manufacturers and implemented in view of the formulation of any suitable international standard.

The traditional tipping-bucket rain gauge is known to underestimate the higher rain rates because of the rainwater amount that is lost during the tipping movement of the bucket [Marsalek, 1981]. Though this inherent shortcoming can be easily remedied by means of dynamic calibration [Calder and Kidd, 1978; Niemczynowicz, 1986], the usual operational practice in meteorological services and instrument manufacturing companies relies on single-point calibration, based on the assumption that dynamic calibration has negligible influence on the total recorded rainfall depth. This results in systematic underestimation of intense rainfall rates that can be quantified – in the case of the SIAP family of rain gauge analysed in our survey – in the range 10-15% at rain rates higher than 200 mm/h. The error increases as a function of the rain intensity and heavily affects the derived statistics, with non-negligible consequences on the numerical estimates of parameters involved in the common statistical tools that are used for the characterisation of extreme events (GEV and TCEV distributions, depth-duration-frequency curves, etc.).

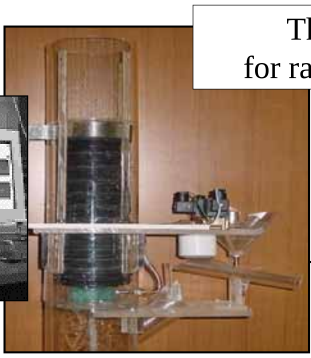


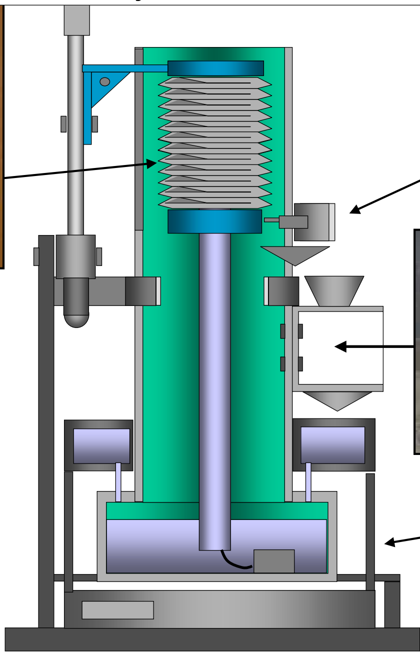
Mechanics of the tipping-bucket rain gauge

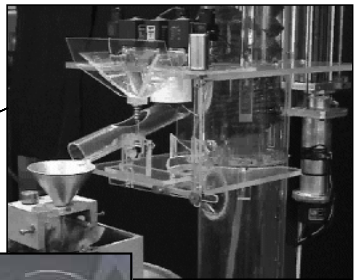


The Final Report of the WMO Expert Meeting on Rainfall Intensity Measurement held in Bratislava during April 2001 includes among its Recommendations that a laboratory calibration test is initiated in order to compare various state-of-the-art methods for rainfall intensity measurements. In order to undertake such an inter-comparison effort further recommendations requires that a standardized procedure for generating consistent and repeatable precipitation flow rates be developed for possible use as the laboratory standard for calibration of catchment type gauges.
At the laboratory of the Department of Environmental Engineering of the University of Genoa, an automatic device has been designed to satisfy such requirements and a prototype realised that is illustrated in this poster. The device, named "qualification module for RI measurement instruments", is based on the principle of generating controlled water flows at a constant rate from the bottom orifice of a container where the water levels is varied using a cylindrical bellow. The water level and the orifice diameter are controlled by software in order to generate the desired flow rate. This is compared with the measure that is contemporary obtained by the RI measurement instrument under consideration and dynamic calibration is possible over the full range of rain rates usually addressed by operational rain gauges.

The developed qualification module for rain intensity measurement instruments





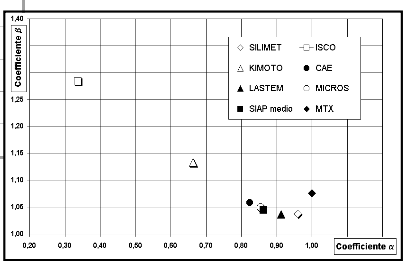


A wide survey of operational rain gauges has been performed in a previous work [Lombardo and Stagi, 1997] - both in meteorological stations and in laboratory tests - on some 60 instruments in the Liguria region of Italy, demonstrating the need of periodic checking using dynamic calibration.
Forty out of the rain gauges analysed are currently used by the National Hydrographic Service in Genoa (Italy), while the others are from private enterprises or different organisations.
Calibration results are expressed in terms of the coefficient of the calibration curve, which is usually assumed as a power law in the form:

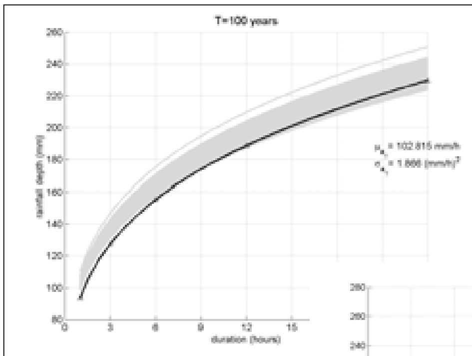
$$I = \alpha \cdot I_R^{\beta}$$

with I the true rainfall rate, I_R the rain rate measured by the gauge, and α and β the calibration parameters. The values of the latter parameters are synthetically reported in the table below for the set of instruments analysed.

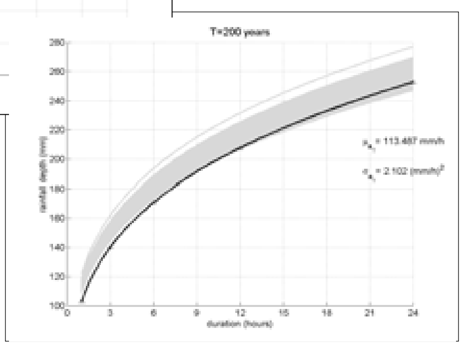
Manufacturer	Number of Gauges	Coefficient α	Exponent β
SIAP	37	0,860	1,046
MTX	1	0,759	1,076
CAE	1	0,824	1,058
SILIMET	1	0,960	1,037
LASTEM	9	1,063	1,058
MICROS	3	0,979	0,986
ETG	1	1,018	0,994
KIMOTO	1	0,663	1,133
ISCO	1	0,336	1,284



Sample results of depth-duration-frequency curves based on corrected (ensemble of 1000 Monte Carlo disaggregation runs – grey shade) vs. original data sets (black line and dots).



Rainfall events of any given duration are largely underestimated, with an error on the associated return period T that can be estimated at about 100% for T = 100 years. More detailed results of this study are already published in La Barbera *et al.* [*Water Sci. Techn.*, **45**(2), 1-9, 2002], where the so-called "equivalent sample size" is introduced as a suitable parameter to quantify the impact of such errors on the common hydrological practice



CONCLUSIONS

The economic impact of standardisation in this field is evident, recalling that the total turnover of the water industry in Europe is estimated to be EU 58,000 million of which the hydrometric element is estimated to be EU 190 million. For many years, the World Meteorological Organisation (WMO) has been publishing its own Technical Recommendations on various aspects of the work, and the International Organisation for Standardisation (ISO) has published, and continues to publish, a large number of International Standards and Technical Reports.
Following the Terms of Reference of the WMO Commission for Instruments and Methods of Observations an expert meeting on rainfall intensity measurements was held and the organisation of a related laboratory inter-comparison is now suggested, together with the introduction of precipitation correction procedures and development of further correction procedures based on simulations. On these basis the need for some further steps towards homogenisation of standard quality of instruments as well as towards the establishment of criteria to assess data quality is more than evident.
The development of a qualification module for RI measurement instruments allowing quality assurance and metrological confirmation of rain gauges according to the European Standard ISO/EN30012-1 is just a first step ahead in this direction, although much work is still required in terms of the accuracy and range requirements, the proper configuration of the calibration equipment, the expected performances and the definition of a standard method of testing. Controlled laboratory conditions should be ensured and a common procedure established that can be easily repeated in any equipped laboratory.