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High resolution performance of catching type rain gauges from the laboratory phase of the WMO Field Intercomparison of Rain Intensity Gauges

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ABSTRACT

The WMO Field Intercomparison of Rainfall Intensity (RI) Gauges started on October, 1st 2007 at Vigna di Valle (Italy) and was concluded in May 2009. Those catching type instruments, out of the selected rain gauges based on various measuring principles, and the four rain gauges selected as reference instruments to be installed in a pit, were preliminarily calibrated in the laboratory before their final installation at the Field Intercomparison site. The recognized WMO laboratory at the University of Genoa was involved in this task, using the same standard tests adopted for the previously held WMO Laboratory Intercomparison of RI gauges. Further tests were performed to investigate the one-minute performance of the involved instruments.

The present paper deals with basically Tipping-Bucket Rain gauges (TBRs) and Weighing Gauges (WGs), using results from tests performed under constant flow rates in laboratory conditions. The objective of this initial phase of the Intercomparison was to single out the counting errors associated with each instrument, so as to help the understanding of the measured differences between instruments in the field during the second phase. Results and comments on the preliminary laboratory calibration exercise are reported in this paper together with their implications for the analysis of the outcome of the Intercomparison in the Field.

1. Introduction

The attention paid to accuracy and reliability in rainfall measurements is currently increasing, following the increased popularity of scientific and practical issues related to the assessment of possible climatic trends, the mitigation of natural disasters (e.g. storms and floods), the hindering of desertification, etc. A reliable quantitative knowledge of the liquid atmospheric precipitation at a specific site on the territory, or over more or less extended regions (catchment basins), is indeed fundamental to a number of investigation threads within the atmospheric and hydrological sciences.

Errors in measurements from traditional and recently developed rain gauges are reported by various authors (Becchi, 1970; Calder and Kidd, 1978; Marsalek, 1981; Adami and Da Deppo, 1985; Niemczynowicz, 1986; Maksimović et al., 1991; Humphrey et al., 1997; La Barbera et al., 2002; Siek et al., 2007), together with suitable proposed methods for either “a posteriori” correction of the measured figures (see e.g. Molini et al., 2005b) or calibration of the gauges.

This notwithstanding, the effects of inaccurate rainfall data on the information derived from rain records is not much documented in the literature (see e.g. Fankhauser, 1997; Molini et al., 2001, 2005a). La Barbera et al. (2002) investigated the propagation of measurement errors into the most common statistics of rainfall extremes and found that systematic mechanical errors of Tipping-Bucket Rain gauges may lead to biases, e.g. in the assessment of the return period T (or the related non-exceedance probability) of short-duration/high intensity events, quantified as 100% for $T = 100$ years. In that work an equivalent sample size is also defined in order to quantify the equivalent number of correct data that would be needed to achieve the same statistical

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uncertainty introduced by the influence of errors on inaccurate records.

In a recent work we also proposed the development of standard limits for the accuracy of rainfall measurements obtained from tipping-bucket and other types of gauges (Lanza and Stagi, 2008), to be used in scientific investigations and as a reference accuracy for operational rain gauge networks to comply with quality assurance systems in meteorological observations.

The focus on precipitation amount is however the major characteristics for most of the available literature reference studies, and reflects the fact that the total accumulated rainfall over periods of time from 3 to 6 h has been the traditional way to account for the precipitation variable up to very recent times in meteorology. Following the increased need to investigate rapidly evolving events at the local to regional scale, with potential tremendous impact at the ground and e.g. civil protection consequences, much consideration has been recently given to rainfall intensity as a new variable.

Precipitation intensity is defined (WMO, 1992) as the amount of precipitation collected per unit time interval. According to this definition, precipitation intensity data can be derived from the measurement of precipitation amount using an ordinary precipitation gauge. In that sense, precipitation intensity is a secondary parameter, derived from the primary parameter precipitation amount. However, precipitation intensity can also be measured directly. For instance, using a gauge and measuring the flow of the captured water, or the increase of collected water as a function of time. A number of measurement techniques for the determination of the amount of precipitation are based on these direct intensity measurements by integrating the measured intensity over a certain time interval.

It is worth noting that the time scales required for calculation of rain intensity at the ground are now much shorter than in traditional applications. The design and management of urban drainage systems, flash flood forecasting and mitigation, transport safety measures, and in general most of the applications where rainfall data are sought in real-time, call for enhanced resolution in time (and space) of such information, even down to the scale of one minute in many cases.

The World Meteorological Organisation (WMO) recognised these emerging needs and promoted a first Expert Meeting on rainfall intensity in 2001 in Bratislava (Slovakia), a location where great part of the activities developed within WMO about atmospheric precipitation had been held in previous years (see e.g. Sevruk, 1982; Sevruk and Hamon, 1984; Sevruk and Klemm, 1989).

The meeting was really fruitful and the outcome recommendations (WMO, 2001) are publicly available on the WMO Web site. Further to the definition of rainfall intensity and the related reference accuracy and resolution, the convened experts suggested to organise an international intercomparison of rainfall intensity measurement instruments, to be held first in the laboratory and then in the field.

The history of instruments intercomparison in the case of rainfall measurements dates back significantly in the last centuries, experiments in the field being reported by Stow (1871) — see Fig. 1 — and recently by Goodison et al. (1998). Previous international rain gauges intercomparison efforts were focused on accumulated amounts of precipitation, low intensity rainfall (snow) and sometimes only on qualitative RI information (light, moderate, and heavy). The analyses therein performed did not focus in particular on quantitative values of RI and no intercomparison of a large number of RI measuring instruments had yet been conducted first in the laboratory and then in field conditions.

The latest international intercomparison effort had the objective to assess and compare counting and catching errors of both catching and non-catching type of rain intensity gauges. One Laboratory Intercomparison was first held at the recognised laboratories of Météo France, KNMI (The Netherlands),

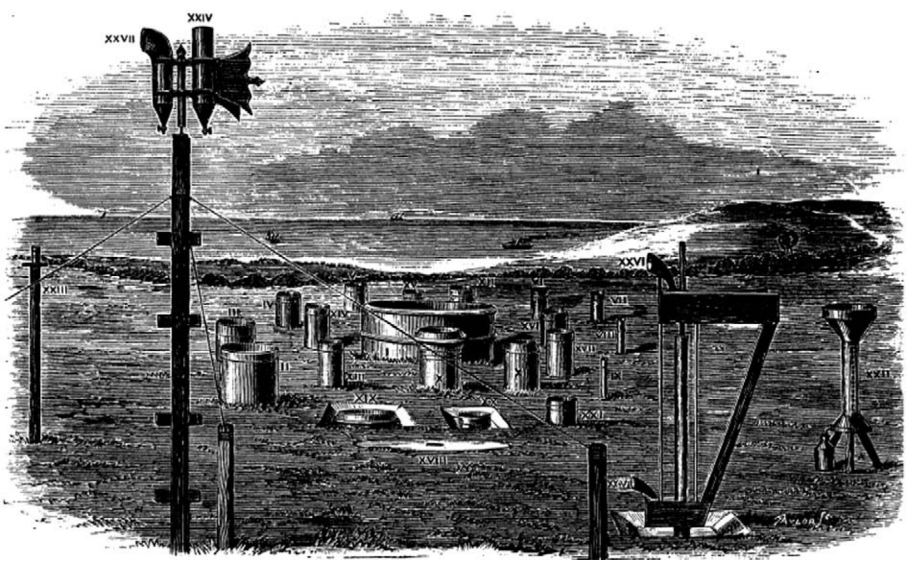

Fig. 1. Symons realizes the first intercomparison of rain gauge instruments at Hawskers — Yorkshire, UK in 1858 (from Stow, 1871 as reported by Goodison et al., 1998).