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Intercomparison of precipitation measured between automatic and manual precipitation gauge in Nepal

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An inter-comparison of precipitation data of manual and automatic precipitation gauge was carried out for four stations of Nepal for the period of 2011–2014. Manual recorded precipitation is used as reference to calculate deviation for automatic recording. This study has attempted to quantify and understand the differences in precipitation amounts between manual and automatic recording. In addition, the possible causes behind the disparity of automatic and manual observational data are also discussed. In case of selected stations, the data quality is fairly satisfactory. The daily deviation between manual recorded and 24 h aggregated automatic recorded precipitation data are calculated for only those days when both gauges are functional. In normal operation the automatic recorded precipitation is underestimated on an average of 10% compared to manual recorded precipitation. The minimum of 5 years of overlapping data still seems to be low for the developing countries like Nepal where timely maintenance, calibration, and up keeping is not possible.

1. Introduction

Department of Hydrology and Meteorology (DHM) operates two networks for in-situ precipitation measurements in Nepal. The first network is a traditional US Standard (8″ diameter) manual rain gauges with long term data set. In this type of network, 24 h precipitation accumulation is manually observed by the local observer every day at 03UTC (8:45 AM local time). The second network is automatic, where precipitation is measured and transmitted continuously in real time with automatic rain gauges. In automatic network, majority of precipitation gauges are tipping bucket types and few weighing gauges are also recently installed in high altitude areas for solid precipitation measurement.

Precipitation measurement has a lot of uncertainties. Therefore, accurate measurements of precipitation on a variety of space and time scales are important not only to weather forecasters and climate scientists, but also to a wide range of decision makers, including hydrologists, agriculturalists, and industrialists [1]. According to Legates and DeLiberty [3] rain gauges may underestimate the true precipitation by about 5%. It is well known that precipitation measurements are affected by losses [8] resulting in under catch. The most important loss results from wind induced errors. These may amount to about 10% for rainfall and 50% for snow. Other losses are e.g. due to wetting of internal walls of the collector and the container when it is emptied and due to evaporation. For automatic rain gauges additional losses may occur due to e.g. the operation of a heating element at low temperatures. [7]. WMO [9] states in its requirements an achievable measurement uncertainty for daily precipitation sums of 5% or 0.1 mm (whatever the largest absolute amount).

According to Theo Brandsma [7] manual measurement has a long continuity in terms of instruments and methods therefore this type of network is very important for climate monitoring, hydrological research and applications. On the other hand, due to high temporal resolution and automatic transmission of data in real time from automatic network, there is a growing need of automatic measurement system for now-casting of flood, weather monitoring and warning, and for study of short-duration extremes. Internationally, there is a trend to expand automatic networks and to decrease, or even to dismantle, manual networks. Given the large errors and varied methodologies of automatic networks, however, the suitability of these networks for climate monitoring purposes may be questioned.

Detailed comparisons are therefore needed between manual recorded (MR) and automatic recorded (AR) precipitation data although we have a rough indication of the differences. There is

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need to continue manual network for climate monitoring purpose and checking the reliability of automatic network. In this regard, World Meteorological Organization [9] has also set clear requirement of at least 5 years of parallel measurement for precipitation.

Since the functioning of automatic weather station is different from manual observation, studies on difference between MR and AR precipitation data are very crucial to validate data and to identify the systematic deviation. This paper describes the comparison of MR and AR precipitation data taking case study of few selected precipitation measurement stations of Nepal with collocated manual and automatic precipitation measurement sites. The main objective of this study is to quantify and understand the differences in MR and AR precipitation amounts. Furthermore, the causes behind the differences are also tried to identify and discussed. Here the comparison is restricted to the period of 2011–2014 and MR precipitation is used as reference in calculation of deviation although they are not absolutely error free.

2. Data and methods

Four meteorological stations (shown in Table 1) from Nepal with collocated manual and automatic precipitation gauge in same observatory are selected for this analysis. These rain gauges are mostly situated in standard observatory having enough open areas required for precipitation measurement. The manual measurement is done by local part time observer recruited in contract basis from DHM, Nepal. The quality of data from stations is ensured by visiting in an average once every 6 months by qualified station inspector from DHM. Fig 1 shows the spatial distribution of precipitation over Nepal (prepared on the basis of 240 stations) where stations selected for this analysis are superimposed in map in red.

2.1. Instruments for precipitation measurement

In the stations, the manual gauge for daily precipitation measurement at 03UTC is US Standard (8″ diameter) rain gauge. It has three components: a large outer container called the outer cylinder, which is 8″ (20.32 cm) in diameter; and 60.96 cm depth, an inner cylinder, which is 63.5 mm (1/10th of collector area) in diameter and about 50.8 cm deep; a collector (funnel), which is 8″ in diameter. A fourth article that completes the set is the measuring stick, which on dipping in inner cylinder gives a water mark for measurement. As the out cylinder is about 600 mm depth, it is the capacity of this type of rain gauge for 24 h precipitation measurement. The collector rests in the top of the inner cylinder. Rainfall is funneled into the inner tube which holds about 50 mm of water when full. If rainfall overfills the inner tube, the excess is collected in the outer overflow can.

For amount less than 50 mm, it can be directly read with dipping stick in inner tube while for amounts greater than that read the full tube (as 50 mm), through it out and then pour the overflow from the outer cylinder into the inner measure tube and then measure it and sum the whole rainfall amount In heavy storms, it may be necessary to pour water into the inner tube several times. In this way observer measures 24-h precipitation sums once per day at 03UTC.

Table 1
Metadata of selection stations.

Station no.	Station name	Measuring type	District	Lon	Lat	Elevation (masl)	Code	Establishment date	Initiation of AR
420	Nepalgunj Airport	Aeronautical	Banke	81.67	28.10	165	NG	May 1996	July 2010
1103	Jiri	Agrometeorology	Dolkha	86.23	27.63	2003	J	Aug 1961	May 2012
1043	Nagarkot	Climatology	Bhaktapur	85.52	27.70	2163	N	May 1971	Aug 2010
904	Chisapani Gadhi	Precipitation	Makwanpur	85.13	27.55	1706	C	May 1956	Aug 2010

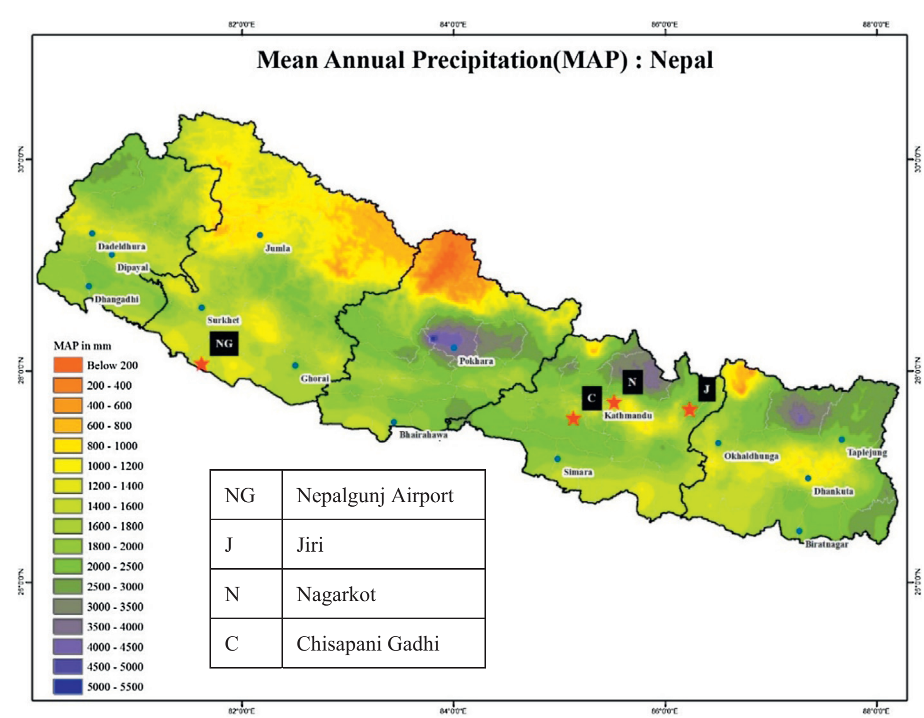

Fig. 1. Map of selected stations (red star) and spatial variation of mean annual precipitation (mm) in Nepal (Karki et al. [2]). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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