A Short Note on Errors in Rainfall Measurement

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Abstract

Daily rainfall data obtsiined from 6 rain gauges set up in 5 different ways are analysed. The effect of wind on rainfall measurements are illustrated and the need for the correction of vertical gauge values when measuring rain on slopes is stressed.

Introduction

Records of man's first attempt to measure rainfall are lost in antiquity. Biswas (1967) notes that rainfall records were collected as early as 400 B.C. and their use indicated knowledge of rainfall amounts, crop requirements and forecasting techniques. Apparently rainfall records in some or other form have been kept for thousands of years with surprisingly little difference between measurement techniques. Ward (1975) notes that since its inception, both the principles and the purpose of precipitation measurement have remained unchanged, the aim being to intercept precipitation over a known, carefully defined area bounded by the raingauge rim, to measure the amount of water so collected, and to express this measurement in units of depth. It is then assumed that this depth of water caught by the raingauge is the same as the depth of rain falling on a large area surrounding the gauge.

Accuracy of rainfall measurement

The measurements produced by well-exposed and well-maintained standard raingauges in areas of minor relief are, for many purposes, sufficiently near the true rainfall. An objective estimate of the volume of water which passes the lowest part of the atmosphere during a given time period is obtained. The result of such measurement is objective in the sense that it is independent of the geometric position of the ground surface or the angle of incidence of raindrops. It is well to recognise however, that the catch of a standard gauge is not the true ground rainfall, namely the amount of rain which would have reached the ground if the gauge had not been there.

The errors that may arise in obtaining a representative sample at a gauge location are referred to as 'local' errors. These include splash in or out, evaporation losses, losses in wetting of the gauge surfaces and inaccuracies due to improper exposure of the gauge orifice. These errors are mostly of such a small nature that they can be ignored but the effect of wind, the major error source, should be considered in measurements where small differences in readings between certain parameters are significant. Wind consequences are not avoided by the usual method of rain gauge installation, particularly at windy sites. The gauge forms an obstacle in the path of the wind thus the wind speed is increased over the gauge orifice and a turbulent eddying effect is produced. Drop trajectories are distorted and drops are carried over the gauge resulting in an underestimate of the fall. At a wind velocity of 3,5 ms^{-1}, air speed over the gauge is increased by up to 37% (Ward, 1975). Hence, all rainfall measurements are relative, a fact not generally recognised. Loss of catch is greatest in storms with small drops and high wind speeds, while tall gauges are more susceptible to loss from wind action than short ones because of higher wind speeds around elevated gauges where the surface friction effect is lower (Court, 1960; Sharon *et al.,* 1976; Rodda *et al.,* 1976).

In an effort to reduce the rainfall distribution effects caused by the gauge in the wind, various forms of shields have been devised. The most popular of these are the Nipher shields, consisting of an inverted cone, and Alter or Tretyakov shields, which consist of a ring of slats around the gauge. The effect of wind shields on rain gauges is to divert the airflow down and around the gauge, thus minimizing updrafts, downdrafts, and turbulent eddies over the gauge orifice. These measuring problems, linked to differences in exposed heights and gauge diameters, result in uncertainties about the accuracy of rainfall data. The W.M.O. Interim Reference Precipitation Gauge was thus introduced in an attempt to provide a basis for comparison, and differences between readings from this and the various national gauges range from 5 to 15 per cent (Ward, 1975).

Measurement of rainfall in undulating terrain

A different approach should be adopted in quantifying rainfall in undulating terrain or in mountainous catchments. Here an additional element comes in, namely, the position of the rain receiving surface in relation to the paths of the falling drops. Rain falls obliquely as a result of wind action, and inclinations of 40° have been reported by Hamilton (1954) and Court (1960). Under these circumstances the windward facing slope will be more thoroughly wetted than a slope facing the opposite direction. Sharon *et al.* (1976) calculated percentage differences in catch between windward and leeward facing slopes for various inclinations of the ground and of the rain vector. These differences vary between 34% and 85%, but a difference of a factor as high as two is possible. On a macro-spatial scale it is possible for these differences to be cancelled out in the sense that what is lost on the one slope is gained on the other and the horizontal catch therefore would give a measure of the mean over the area. In many instances this does however not apply, and it thus necessitates the use of inclined gauges or gauges with the orifices lying in a plane parallel to the sloping surface concerned. Several types of stationary and rotating directional rain gauges are in use of which the installation and functioning are, amongst others, discussed by Hamilton (1954); van Heerden (1961); and Sharon *et al.* (1976). The rain vector is the basis on which the design of the directional rain gauges rests. Van Heerden (1961) states that the direction and magnitude of showers