A NOTE ON RANDOM RAIN-GAUGE ERRORS

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ABSTRACT

By using 12 standard rain gauges on a small site, the random errors of rain-gauge measurements were assessed both for individual storms and for monthly totals. It is shown that random errors can be considerable even without taking into account known systematic errors.

INTRODUCTION

It is known that errors in measuring rainfall using rain gauges arise from a number of systematic causes, including the siting of the instrument, its height above the ground, and varying wind speeds over the gauge orifice. There is also a random error which cannot be ascribed to any particular cause. This random error is the subject of this note.

In an experiment concerning the accuracy of rain gauges, being carried out at an exposed site at an altitude of 1,850 ft on Mount Cargill, Dunedin, it was considered necessary to establish that there were no variations in rainfall across the site, which measured 30 ft × 50 ft. This was done by placing 12 standard rain gauges randomly over the site, and recording the catch in each gauge after each rainstorm for the period 20 August to 2 December 1968. The results established that the site was homogeneous for the experiment, but the purpose of this note is to show that it is possible for an assessment of the random variation to be made using this technique.

RESULTS

Readings from 21 individual storms, together with three monthly totals, were analysed by calculating the means, standard deviations and coefficients of variation for the storms and the rain gauges.

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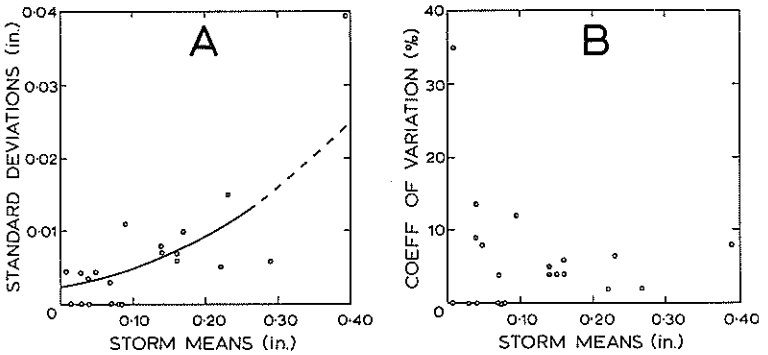

FIG. 1 — (A) Storm means vs. standard deviations.
(B) Storm means vs. coefficients of variation.

Fig. 1(A) shows that, for individual storms, the standard deviation increases with the mean rainfall value for the 12 gauges, while Fig. 1(B) shows that the coefficient of variation is independent of the mean.

The monthly values for the three months (Table 1) show standard deviations of the same order as for the individual storms, but with lower — almost negligible — coefficients of variation.

TABLE 1 — Expected error of single rain-gauge readings for specified confidence limits.

Mean	*Standard deviation (in.)*	*Coefficient of variation (percentage)*	*Error (±) in inches for confidence limits of:* 50%	95%	99.7%
Individual storms					
0.10	0.005	—	0.003	0.010	0.015
0.20	0.009	—	0.006	0.018	0.027
0.30	0.016	—	0.011	0.032	0.048
0.40	0.025	—	0.017	0.050	0.075
Months					
1.49	0.031	2.1	0.021	0.062	0.091
2.05	0.021	1.0	0.067	0.042	0.063
3.42	0.039	1.2	0.081	0.078	0.117

The interest in these results lies in the possibility of being able to assess the random error of a single rain gauge. Assuming a normal distribution for the readings from the 12 gauges for the individual storms, it is known that an individual value will lie within limits set by the standard deviation with a specified confidence, shown in Table 1. This table has been calculated for individual storms by drawing by eye a line representing the relationship

between standard deviation and mean value, taking off the standard deviation for appropriate mean values, and applying normal distribution theory. For the monthly totals the actual values are given.

It will be seen that quite considerable random errors may occur; for example, a reading for an individual storm of 0.40 in. could represent a true value of between 0.32 and 0.48 in. This random variation also explains why, as shown in a previous paper (Hutchinson, 1969), using ordinary network stations, the fall-off of correlation with distance between a key gauge and other gauges in the area rarely attains a value of 1.0 even where the distance is zero.

CONCLUSION

It is not suggested that the random variation will always be of the magnitude indicated, as this is possibly dependent on the nature of the rain-gauge site. However, with the near certainty that systematic errors will also arise, it is not surprising that considerable attention is now being paid to trying to establish 'true' rainfall.

ACKNOWLEDGMENTS

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REFERENCE

Hutchinson, P. 1969: The estimation of rainfall in sparsely gauged areas. *Bull. Internat. Assoc. Sci. Hydrol. 14* (1): 101–119.