MONTHLY PERSISTENCE PATTERNS OF AUCKLAND RAINFALL YIELDS

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ABSTRACT

A chi-square (χ^2) test is used to determine the persistence pattern of the monthly rainfall data obtained from Albert Park, Auckland. The results indicate the months for which the rainfall yields are affected by the amounts of rain of the immediately preceding month.

INTRODUCTION

Where an area is subject to the influences of large-scale climatic phenomena, the local weather patterns show features of persistence — at times for several weeks. The persistence may influence consecutive months of weather patterns and rainfall yields recorded in those months. In such cases, statistical independence between monthly yields would not exist.

The serial correlation coefficient (Hoel, 1962), defined as

$$\rho(k) = \sum_{t=1}^{N-k} x_{t+k}$$

where N is the total number of observations, x_t, and k is the number of lags, is commonly used to determine the existence of any persistence effects. This coefficient, $\rho(k)$, computed at various lags, k, of the data, is a relative measure of the degree of persistence. However, this test implies that persistence, if it exists, is equally active throughout the recorded monthly rainfall sequence. In other words, it does not give the pattern of persistence effects, but only evidence of its existence. For example, the serial correlation coefficient $\rho(1) = 0.172$, computed for the Auckland monthly precipitation record, gives no evidence of significant persistence effects. The question that needs to be answered is whether or not this can be assumed to represent the real situation. The real situation may be such that persistence effects are limited to a few pairs of months

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only. When this effect is averaged over the rest of the year, as in the serial correlation test, the result may become insignificant. Thus, a more specific test is required to determine which months of the year influence the rainfall of the immediately succeeding month.

CHI-SQUARE TEST

A method to test for persistence of this type would be to check whether the sign of the deviation of the monthly rainfall yield from its monthly mean is consistently followed by a similar deviation in the following month. This can be achieved by using a standard statistical test for independence in a 2×2 contingency table (Wetherill, 1967).

TABLE 1 — Deviation of monthly rainfalls from the mean.

		Month (m+1)		
		Below mean	*Above mean*	*Total*
Month (m)	*Below mean*	a	b	a+b
	Above mean	c	d	c+d
	Total	a+c	b+d	a+b+c+d

Table 1 represents the frequency of occurrence of monthly rainfall yields above and below the respective means of two consecutive months. A χ^2 test statistic

$$\chi^2=\frac{(ad-bc)^2\,(a+b+c+d)}{(a+b)\,(a+c)\,(b+d)\,(c+d)}$$

is used as the criterion of acceptance or rejection of the null hypothesis of independence. The null hypothesis is rejected if

$$\chi^2>\chi^2_{\alpha,d}$$

where $\chi^2_{\alpha,d}$ is obtained from χ^2 tables corresponding to α, the level of significance, and d, the number of degrees of freedom. For a 2×2 contingency table the number of degrees of freedom, d, is one.

RESULTS

The 115 years of complete monthly rainfall records for Auckland were tested for persistence. The χ^2 test was applied to the consecutive pairs of months throughout the whole year. Computations were performed on an IBM 1130 computer.

The null hypothesis of independence between observations was rejected if $\chi^2>\chi^2_{\alpha,d}=3.84$ for $\alpha=5\%$ and $d=1$. Results of the test statistic χ^2 are listed in Table 2.

TABLE 2 — Results of applying the test statistic χ^2 to Auckland rainfall records. Persistence is assumed if $\chi^2 > \chi^2_{\alpha,1} = 3.84$. The level of signicance $\alpha = 5\%$ An asterisk indicates the months where persistence effects exist.

Months	χ^2
January–February	9.963
February–March	1.301
March–April	6.269*
April–May	0.647
May–June	0.382
June–July	2.106
July–August	5.537*
August–September	0.077
September–October	0.036
October–November	0.742
November–December	9.853*
December–January	2.098

CONCLUSION

From these results, only three months of the year are affected by the immediately preceding month, viz March–April, July–August, November–December. It is interesting to note that the correlated pairs of months occur at equally spaced intervals, i.e. every 4 months.

Thus by the serial correlation coefficient the persistence effect is insignificant, whereas the χ^2 test indicates strong persistence effects between certain pairs of months of the year. This persistence pattern could be an important factor in some hydrological studies, for example in simulation of monthly rainfall data for water-resource studies.

REFERENCES

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