LETTERS TO THE EDITOR

Comment on Editorial "Units, Coefficients and Dimensions" by S. M. Thompson (Journal of Hydrology (N.Z.) 19(2), 1980).

In a recent editorial S. M. Thompson (1980) attempts to show how dimensional analysis may be used to guide investigation; in particular, of the regionalisation adopted by Beable and McKerchar (1982) in their enquiry into mean annual flood prediction within New Zealand.

The purpose of this letter is to discuss his analysis; to correct some errors; and to suggest a further approach to the regionalisation problem. Points at issue are not all independent, but are conveniently discussed separately. They include:—

(1) There is implied concern that the quoted formula of Beable and McKerchar (1982) (Equation 1 in Thompson (1980)) given as—

$$Q=8.84 \times 10^{-5} A^{0.76} (86.4 I)^{2.24}$$

is not dimensionally consistent. We agree with Bagnold (1980) that with a purely empirical relation of this kind, any attempt to remove a dimensional discrepancy should be dismissed as speculative. Nevertheless, it is preferable to write the equation in a form independent of the system of units used. This can be done simply by replacing each of the variables with a non-dimensional ratio corresponding to a reliably determined reference value.

(2) In Equation 8 of Thompson (1980), which is

$$L=50000A^{0.2}$$

dimensions of metre$^{0.6}$ are assigned to the number 50000. This is an error: dimensions must not be given to numbers for then any equation could be regarded as dimensionally homogeneous. What perhaps should be said, is that this empirical equation is dimensionally incomplete, the missing dimensions being length$^{0.6}$.

(3) Time of concentration, t_c, is defined as the duration of the rainfall which at the return period of Q($\simeq$2 years) has the intensity, Q/A. The formula (Equation 5 in Thompson (1980)) assumed for t_c is

$$t_c=L/(Q/A)$$

where L is a "length scale representing both the catchment size and the roughness which retards flow, and is Snyder's coefficient C_p". There are two errors here: first, L is not equal to C_p as C_p is dimensionless (Snyder 1938); and second, L, the product of t_c and Q/A, is duration of rainfall times rainfall intensity which is a rainfall depth, in conflict with the given description of L.

(4) One purpose of dimensional analysis is to reduce the number of parameters in a problem and not to increase, as in Thompson (1980), for the more parameters, the more difficult it is to ascertain their functional relations. (An elegant example concerning flood runoff which demonstrates both this point and the general power of dimensional analysis, is given by Langhaar (1951, p. 111-113)).

Specifically Thompson (1980) introduces two new parameters, e and L, both of which are arbitrary for they depend upon the definition of t_c (Equation 5 in Thompson (1980)) which need not be linear for example.

Consideration of e and L is also limiting in that the given method for their evaluation is applicable to only 4 of the 9 regions prescribed by Beable and McKerchar (1982).

For further investigation of the regionalisation problem (in addition to the statistical work of Mosley (1981)) we suggest a traditional, empirical approach. The relevant variables found by Beable and McKerchar (1982) are Q, A, I, P where P is catchment mean rainfall and Q is dependent: the procedure is to hold, say A and I constant (by choosing catchments with similar values of A and I) and to determine the Q-P relation, followed by A and P constant to find Q-I and so on. Using data from North Island, New Zealand, and, for comparison, power-law models of the above relations, preliminary calculations yield (approximately)

$$Q \propto A^{0.5} I^{1.5} P^{1.0}$$

Beable and McKerchar (1982) deduced by multiple regression techniques

$$Q \propto A^{0.83} I^{1.89} P^{1.07}$$

The point is that, in agreement with Mosley (1981), we could not make a strong case for regionalisation anywhere in our brief enquiry: we do not deny, however, that regionalisation is possible. If there is sufficient data of known reliability to perform our procedure rigorously, then the method should assist in solving the problem.

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