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The shaky empirical foundations of soil-erosion models

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All soil-erosion models are constrained by the empirical base upon which their parameterization rests, much of which dates from experiments and technologies of a generation ago. It is easy for modellers to overlook, or even be unaware of, the limitations of this empirical base. Thus far, technological limitations have constrained experimental work to steady state measurements for what is actually a highly dynamic process. There is no strong support for assuming that an equation derived conceptually for steady state conditions should be a good basis for a model of unsteady erosion. This paper reviews the empirical basis of some of the commonly used equations in erosion models, and assesses the sensitivity of erosion models to uncertainty in these empirical equations. Two examples illustrate this problem. First, the control by rainfall intensity on interrill erosion is expressed in a widely used relationship in which E (interrill soil loss - g m^{-2} s^{-1}) is expressed as the product of I (rainfall intensity - mm s^{-1}) to the power b and a constant a. In most models, based upon empirical studies, b is given a value of 2, and a is assumed to vary with soil type. Yet there is evidence to suggest that both the value of b and the assumption about a are incorrect. Secondly, the Marshall-Palmer model for raindrop size distribution that frequently underpins rainfall intensity-kinetic energy relationships in soil-erosion models has been shown to be inappropriate for the high-intensity rainstorms that cause most soil erosion, and uncertainty in the drop-size distribution of rainfall has a significant effect on predicted rates of interrill soil erosion. Evaluation of the success of soil-erosion models must include an evaluation of the strength and inherent uncertainty, of their empirical foundations. Associated with this evaluation there needs to be a programme of ongoing research to improve these foundations, that is guided by modelling needs. The development of robust models is prevented by the empirical limitations of current process understanding because of reductionist approaches that have hitherto been taken to the characterization of different model components.