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Discussion

Investigating prediction capability of HEC-1 and KINEROS kinematic wave runoff models — Reply

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The points raised by Smith and Goodrich (1996) can be summarized briefly as follows:

(1) HEC-1 is not physically based in its treatment of infiltration and this invalidates the evaluation.

(2) Choice of catchment is faulty.

(3) The authors did not use the same information for HEC-1 and KINEROS models; the procedure used in determining infiltration parameters for KINEROS is contrary to the recommendations for Woolhiser et al. (1990).

(4) The authors failed to state that, from Table 5, KINEROS is superior to HEC-1; and also failed to do an objective comparison of observed vs. predicted hydrographs for KINEROS as was done for HEC-1.

(5) It is not clear why FMIN was kept below 0.7 cm h^{-1} and also why, in the second exercise, CNSTL in HEC-1 was not adjusted since FMIN was adjusted in KINEROS.

Our response follows:

It is true that the infiltration algorithm of the HEC-1 model is not as exacting as that of KINEROS. We fail to see the relevance when the objective is to compare the output of the two models.

One hopes that Smith and Goodrich do not seriously consider the choice of catchment in this study a vexing issue. In any case, the choice of catchment did not violate any restrictions imposed by either KINEROS or HEC-1 models.

Duru and Hjelmfelt (1994, p. 89) stated that HEC-1 and KINEROS models treat infiltration differently. This includes using totally different parameters as well as using the same parameter in different forms. For example, whereas HEC-1 accounts for antecedent moisture with initial abstraction, KINEROS accounts for the same condition using initial relative moisture saturation. Also, KINEROS uses effective

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net capillary drive while HEC-1 does not. It is, therefore, not meaningful to talk about using the same 'information' for the two models. We attempted to determine the model parameters as recommended by the model developers.

Smith and Goodrich (1996) imply that we determined the infiltration parameters for KINEROS in a manner contrary to the recommendations of Woolhiser et al. (1990) and quoted a recommendation from Woolhiser et al. (1990, p. 49) to support that assertion. Unfortunately, they quoted only a portion of the recommendation. A better appreciation is gained from the complete recommendation:

> These parameters can be estimated in many ways. Infiltration data can be analyzed to obtain fitted values, or natural runoff events can be studied to identify best fit values of these infiltration parameters using a surface water routing model such as KINEROS. This is a difficult procedure, because (1) measurement errors can be crippling and (2) the two parameters exhibit a certain interaction in terms of total runoff from a given storm (Wisheropp, 1982). The parameters can also be determined from unsaturated soil hydraulic characteristics, but these are most often unavailable. If textural class of the soil is known – for example, clay loam, silt loam, sandy clay loam – the parameters may be estimated based on the tabulations of Rawls et al. (1982). Table 2 is taken from that report and gives approximate values of hydraulic characteristics to be expected from several soils.

In our study, values from the Table 2 referred to were used, as is stated on p. 96 of our paper. It is also pertinent to note that Woolhiser et al. (1990, p. 69) used values from Table 2 in an illustrative example in the KINEROS user manual. In retrospect, it may have been revealing to use the equilibrium infiltration rate as equivalent to saturated hydraulic conductivity (K_s).

We stated explicitly (on p. 101 of our paper) that both models simulate the runoff hydrograph very well when calibrated to individual events. If Smith and Goodrich wish to go further to state that, "from Table 5, KINEROS is superior to HEC-1", we find no need to contest the assertion.

The Nash–Sutcliffe efficiency statistic for objective hydrograph comparison was not presented for KINEROS. This was because, as stated on p. 96 of our paper, we were unable to obtain a consistently accurate prediction of the observed hydrograph with KINEROS when infiltration parameters were estimated from soil type, antecedent moisture condition, and vegetative cover (Objective 1 of our study). We saw no value in doing the test as this would, most certainly, have shown the same result. Having made a statement on our finding, we did not see any need to dwell on the issue.

The reason to keep FMIN below 0.7 cm h^{-1} is this: Woolhiser et al. (1990) had given the value of K_s (coded in the KINEROS program as FMIN) for silt loam soil as 0.7 cm h^{-1} and had recommended (p. 69 of the KINEROS user manual) that under imbibition FMIN should be $K_s/2$. It certainly would have been a violation of the recommendation if we not only made FMIN $> K_s/2$ under imbibition but also allowed FMIN $> K_s$. If we had, however, set aside the manual recommendations and made $K_s = 1.3$ cm h^{-1} (see response 3 above), then FMIN could have taken an upper limit of 0.7 cm h^{-1}.

The reason for not varying CNSTL in the second exercise is very clear from the procedure outlined on p. 89 of our paper, and follows from the preceding paragraph. In the first exercise, initial moisture loss (used by HEC-1) and initial relative moisture saturation (used by KINEROS) were assigned values from descriptive information on soil type, moisture status, and geographic features of the catchment. At this point, CNSTL in HEC-1 and FMIN in KINEROS were taken as already established values (CNSTL = 1.3 cm h^{-1} from University of Illinois Agricultural Experiment Station, 1979, and FMIN = $K_s/2$ from Woolhiser et al., 1990). These two values were assumed to be correct and were kept constant. Together with the assigned antecedent moisture index, these were used in the respective models to predict the observed hydrographs. In the second exercise, only initial abstraction (in HEC-1) and initial relative moisture saturation (in KINEROS) were, at first, adjusted in an attempt to improve on the predicted hydrograph. Whereas this adjustment of the one parameter gave excellent results for HEC-1, it failed to give good results for KINEROS. This led us to suspect that the value we had assumed to be correct for FMIN may not have been.

Hydrologic models are most widely used in cases in which little or no observed data are available for comparison. In these cases, the criteria for goodness of application are limited to reasonableness of the answer and ability to use the model with the data at hand. To apply a model in a case in which data are available for comparison leads to a variety of scenarios. There is the problem of selecting the most representative events and the problem of the ability to run the model properly. Often this process of learning to run the model includes discovering bugs, getting bugs fixed, or finding a 'work-around to avoid bugs'. Seldom is the model process as smooth as desired. We wish to express our appreciation to both Smith and Goodrich for their extensive discussions with us concerning parameter selection and model application, and for dealing with coding problems discovered in the early version of the KINEROS model.

We, like Smith and Goodrich, are disappointed in the results of our investigation as we remain committed to the objective of physically based hydrologic modeling.

Errata

There is an error in Table 2, column 4 of our paper. The "Estimated constant moisture loss" given as 0.5 has the units of in h^{-1}. The value should have been converted to 1.3 cm h^{-1}.

References

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