Discussion of “Application of a Nonstandard Explicit Integration to Solve Green and Ampt Infiltration Equation” by Damodhara R. Mailapalli, Wesley W. Wallender, Rajendra Singh, and Narendra S. Raghawanshi

DOI: 10.1061/(ASCE)1084-0699(2009)14:2(203)

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The discusser would like to thank the authors for proposing quick nonstandard explicit integration algorithm (EIA) to solve the Green and Ampt equation. The discusser, however, would like to add a few points.

Considering parameters \( A \) and \( B \) as a constant and integrating Eq. (3) of the original paper yields

\[
t = \frac{1}{A} \left[ I - I_0 + B \ln \left( \frac{I + B}{I_0 + B} \right) \right]
\]

(1)

Eq. (1) can be used ‘as a base’ to evaluate the accuracy of the proposed explicit integration algorithm (EIA). Cumulative infiltration at a particular time can be obtained by Eq. (1) and using numerical iteration techniques such as Newton-Raphson.

As mentioned in the original paper the accuracy of the proposed method (EIA) depends on time step size. Considering tolerance level equals to \( 10^{-12} \), the percentage error of EIA is calculated and illustrated in Fig. 1 for dry and wet soil cases.

As seen in Fig. 1, the accuracy of the proposed method depends significantly on the time step size particularly in initial moments. This algorithm is an efficient one to solve the Green and Ampt infiltration equation if small step size is used. On the other hand, small time step size increases the computational time and cost.

Since an accurate and simple explicit algebraic equation can be more efficient than an explicit numerical integration technique, an explicit equation is proposed by inversion of Eq. (1) as follows:

\[
I = B(\delta_1 - 0.4187\delta_2^{0.819} + 1.55\delta_2^{6.51} + 0.0145\delta_2^{13.85}) + I_0
\]

(2)

in which

\[
\delta_1 = -\ln \left( \frac{1 + \frac{I_0}{B}}{B} \right) + \frac{A}{B} t
\]

(3)

The maximum percentage error of Eq. (2) in the below practical range is less than 0.2%:

\[
\frac{I_0}{B} - \ln \left( 1 + \frac{I_0}{B} \right) + \frac{A}{B} t < 20
\]

(5)

This equation is also simple enough for routine use. For two soil cases mentioned in the original paper the percentage error of Eq. (2) is calculated (tolerance level=\( 10^{-13} \)) and illustrated in Fig. 2. As seen, the maximum relative error is less than 0.2%. It should be noted, both cases have approximately the same error.

However, for a particular time, the EIA estimates cumulative infiltration explicitly in a single step; which can save computational time and cost compared with other conventional multistep algorithms, this algorithm is not as efficient as the proposed algebraic equation to solve the Green and Ampt infiltration equation explicitly.

Fig. 1. Percentage error of EIA for different time step size (a) dry soil case; (b) wet soil case

Fig. 2. Percentage error of proposed explicit equation for (a) dry soil case; (b) wet soil case