MODELING SPATIAL VARIABILITY OF FIELD-SCALE SOLUTE TRANSPORT IN THE VADOSE ZONE

by

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(ABSTRACT)

Spatial heterogeneity in the soil system has a profound influence on the flow of water and chemicals in the unsaturated zone. Incorporating intrinsic soil variability and extrinsic variability into root zone leaching models will provide a better representation of pollutant distribution in natural field conditions.

In this study, a stochastic framework (SF) was developed to represent spatial variability of soil properties in one-dimensional solute transport models, and implemented with two existing root zone leaching models, Opus and GLEAMS. The accuracy of soil water, bromide and pesticide transport predictions from Opus-SF and GLEAMS-SF was evaluated using field-measured soil water content, bromide and pesticide mass data from a 3.9-ha agricultural field in the Dougherty Plain of Georgia and a 0.05-ha field plot in Nomini Creek watershed in Virginia. Results from the rate-based Opus-SF and capacity-based GLEAMS-SF were compared to determine if there were significant differences in their predictions.

In the stochastic approach, the heterogeneous field is conceptualized as a collection of vertical, non-interacting soil columns differing in soil properties. The horizontal variations of soil hydraulic and retention properties in each horizon are treated as random functions of zero transverse spatial correlation length, after accounting for any spatial trends. The spatially variable parameters were generated using the Latin hypercube sampling method, and the stochastic simulation of the model was performed using Monte-Carlo simulation techniques.

Statistical tests indicated that Opus-SF and GLEAMS-SF did not predict the central tendency and distribution of depth-averaged soil water content and total pesticide mass observed in the field on most

sampling dates. But their predictions were sufficiently accurate for most management-type applications. Soil hydraulic and retention properties derived from texture data at the Nomini Creek site substantially reduced the variability in soil water content predictions from both models, but had less impact on bromide and pesticide mass predictions from both models.

The mean values predicted by Opus-SF and GLEAMS-SF were similar, but not equal to those predicted by the deterministic version of the models. Soil water and solute transport predictions from Opus-SF and GLEAMS-SF were not substantially different from corresponding results from the traditional Monte-Carlo approach, although soil water predictions from the two modeling approaches were significantly different for the first 150 days of simulation. Comparison between results from Opus-SF and GLEAMS-SF showed that the distributions and medians of soil water content predicted by the two models were significantly different on most sampling dates. The distributions and medians of pesticide mass predicted by the two models were closer than soil water content, but were significantly different on more than half of the field sampling dates.

The more functional GLEAMS-SF model was able to simulate depth-averaged soil water content in the root zone better than the more physically based Opus-SF, although GLEAMS-SF was not able to simulate the depth distribution of soil water as accurately as Opus-SF. GLEAMS-SF was also able to predict solute movement at least as well as Opus-SF. GLEAMS-SF was able to simulate spatial variations of depth-averaged soil water content and pesticide mass in the field with reasonable accuracy employing fewer parameters that exhibit relatively lesser spatial variability.

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