Geophysical Research Abstracts, Vol. 7, 05103, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05103

Quantification of uncertainty within predictions of water transport in vegetated lysimeters

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A model describing unsaturated flow in vegetated soil has been developed, coupling plant feedback mechanisms with a finite-difference implementation of Richards' equation. While care has been taken to relate all parameters and processes to physically realistic analogies, moderate uncertainty in a range of parameters is unavoidable due to the need for characterisation of soil hydraulic properties and the complexity of plant water processes.

Confidence in model effectiveness has been addressed through simulations of lysimeter experiments conducted in Southern England. Measurements on eight lysimeters divided into two sets of four were taken, with the two sets containing different soil types. The water table was maintained at 65 cm below the soil surface, and all eight lysimeters supported a sward of perennial ryegrass (*Lolium perenne* cv. Profit). Detailed soil and climate measurements were taken at intervals of one hundredth of a day, in order to monitor the internal hydrological status of the lysimeters and the external forcing conditions. Both diurnal variation and seasonal responses are particularly clear in the resulting data set.

This paper describes the application of sensitivity and uncertainty analysis to the model, using this detailed data set. In the performance of the optimisation process, good quality of model definition at both diurnal and seasonal scales is treated as particularly important, as is the effect of measurement error on parameterisation at these different scales.

Matric potential, moisture content, and lower boundary flux data present a high degree of constraint on the hydrological model's calibrated parameter sets, while the matric potential and moisture content measurements are also used to further constrain the moisture characteristic curve. The extent to which a single non-hysteretic hydraulic characterisation can represent the data is interrogated. Other uncertainties are also detailed, and, where possible, quantified.

Classic and Markov chain Monte Carlo routines are then used to sample an eight-dimensional parameter space (of soil hydraulic and plant stomatal resistance parameters). The effect of different levels of uncertainty is then examined, as is the ability of the model and framework to recover a reasonable parameter fit to such a detailed, highly constrained dataset.

Results confirm problems of identifiability and equifinality found with other datasets, where a wide range of parameter combinations produced coincident results. Furthermore, *a priori* constraining of parameter sets to fit the moisture retention data reduced the ability of the model to reproduce the observed water fluxes.