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Development and testing of a physically-based, three-dimensional model of surface and subsurface hydrology

M. Bittelli, A. Pistocchi, F. Tomei, M. Flury, E. S. Brooks and J. Boll

Department of AgroEnvironmental Science and Technology, University of Bologna, marco.bittelli@unibo.it

The paper describes a phyisically-based, fully coupled, catchment-scale model that solves equations of surface and subsurface flow in a three-dimensional domain. Surface flow is described by the two-dimensional parabolic approximation of the St. Venant equation, using Manning's equation of motion; subsurface flow is described by the three-dimensional Richards' equation, using an integrated finite difference formulation. The model directly interfaces with GIS data and also incorporate algorithms for topography dependent solar radiation, snowmelt, evapotranspiration and root water uptake. We tested the model by comparing: (a) simulated and observed soil water contents for a field experiment with one-dimensional flow, and (b) distributed three-dimensional simulated and observed perched water depth (PWD), stream flow data and soil water content for a small catchment. Numerical experiments were performed with respect to space and time discretization. The model successfully described the water balance and in each experiments. Moreover, the model met convergence, approximation, and computational speed criteria, which allow its use on common desktop computers.